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Yambuku

E B O L A

Men who never have had the experience of trying, in the midst of an epidemic, to remain calm and keep experimental conditions, do not realize in the security of their laboratories what one has to contend with.

—Dr. Martin Arrowsmith, from *Arrowsmith*, Sinclair Lewis

I

Mabalo Lokela was in a great mood. Sure, he had a fever, but it was undoubtedly just the malaria again. He was sure of that. The important thing was that he was back from a great vacation—one of the few he'd had in his forty-four years.

While he waited for one of the Sisters to give him malaria medicine, Mabalo shared with colleagues at the Yambuku mission stories of his recent travels. From August 10 to August 22 he and six other mission employees had driven around the far north of Zaire, visiting towns all over the Mobaye-Bongo Zone, sampling local delicacies and enjoying the sort of sightseeing that was rare for people in the Bumba Zone. It was possible to travel such distances—it must have been hundreds of miles!—only because Father Augustin was with them: his presence allowed the use of the mission's Land-Rover.

"We got all the way up to Badolité, and we would have crossed over into the Central African Republic, but the bridge was down," he told friends at the mission. When he got back to Yambuku four days ago, Mabalo (whom friends called Antoine) was so happy to be home that he spent a good bit of his schoolteacher income buying fresh antelope meat in the market—something to please his wife, Mbuzu Sophie. Sophie, who was eight months pregnant, dried the meat and made a stew for the family celebration of Antoine's return.¹

Antoine watched as one of the Belgian Sisters prepared a syringe, and gritted his teeth when the needle punctured his skin. "Chloroquine," she told him as he rubbed his arm, "will cure your malaria." He nodded, confident that all good cures come from needles.

Two days later, on August 28, 1976, a thirty-year-old man came to the

Yambuku Mission Hospital complaining of terrible diarrhea. Though nobody at the mission recognized the man, he told the Sisters that he came from the nearby village of Yandongi. Well, his origins were no matter; the Sisters treated any needy soul who crossed their threshold, sometimes 400 a day, many of whom walked and hitched rides distances of fifty or sixty miles to reach the mission. Most of the sick got injections of one kind or another: antibiotics, chloroquine, vitamins—whatever supplies might be on hand in the modestly funded remote Catholic hospital. And usually that was enough for the people, who would, in any event, supplement whatever the Belgian nurses gave them with potions, incantations, and injections from local sorcerers.

But the case of the man from Yandongi was odd, and Sisters Béata, Edmonda, and Myriam weren't quite sure what was the source of his illness. They put the man in one of the 120 beds in the hospital and, for two days, debated his diagnosis, finally writing in his medical chart a vague "dysentery and epistaxis."²

After two days the man left the hospital against the Sisters' wishes, his diarrhea and epistaxis, or severe nosebleed, still unresolved. He was never seen again, though events days after his disappearance would prompt dozens of investigators from all over the world to scour villages throughout the Bumba Zone in search of the elusive patient.

The Bumba Zone lay in Zaire's northern frontier, spanning savanna and dense rain forest lands between the Ubangi and Zaire (formerly Congo) rivers. Some 275,000 people lived in the Zone, most in villages of fewer than 500 people. They earned their living growing cash crops for export to the Zairian capital, Kinshasa, and by hunting. The equatorial jungles and grasslands were rife with game that included such marketable delicacies, pelts, and riches as green monkeys, baboons, black-and-white colobus tree monkeys, chimpanzees, spotted-necked otters, mongooses, civets, elephants, hippopotamuses, bushpigs, buffaloes, bongos, sitatunga antelopes, bushbucks, reedbucks, and oribi.³

Since 1935 the major hospital and dispensary for some 60,000 villagers living in the central Bumba Zone was that operated by Belgian Catholic missionaries in the village of Yambuku. A staff of seventeen "nurses"—so designated, though none of the Sisters had attended a certified nursing school—and medical assistants tended to the health needs of the community out of a rather modest set of cinder-block buildings. As one entered the front of the hospital, administrative offices were in a room on the right, followed by a pharmacy, and a surgical block comprised of an operating theater, scrub room, and facilities for "sterilizing" instruments: a thirty-liter autoclave and a Primus stove atop which water boiled.

Outside the surgical block one entered a long alleyway. To one side of the alley was a pavilion bisected by a hall, off of which were large hospital rooms: one common ward with eighteen beds, four eighteen-bed men's wards, and three larger women's wards. As was common throughout Central

Africa, the beds were flat metal ones made tolerably comfortable with thin mattresses and ancient linens. Additional comforts and foods to supplement the basic rice or mealie-meal menu were provided by patients' relatives.

Further along the outer alleyway was an outpatient clinic, through which flowed dozens of people every day seeking prenatal care, injections for a variety of ailments, vaccines for their children, and advice from the Sisters about all sorts of health problems.

There was no doctor in Yambuku. Patients were treated by the staff of four Belgian nuns who had received a modicum of training in nurse-midwifery, a priest, one Zairian female nurse, and seven Zairian men.⁴

This small team of hardworking health providers also monitored patients in another building housing a large ob-gyn ward and two more general medicine wards. The hospital was part of a larger mission complex that included a school where Antoine worked, a church, a variety of other service buildings, and the living and dining quarters of the missionaries. In addition to those working in the hospitals, the missionaries included several more Belgian nuns and priests who staffed the schools, the church, and other facilities.

Though his home was in the village of Yalikonde, about a mile from Yambuku, Antoine spent days on end at the mission, as did two of his older teenaged children. So it was natural that he returned to the Sisters on September 1 when, despite the chloroquine injection, his fever soared over 100°F. They checked his vital signs and told Antoine to rest for a few days. Antoine returned to Yalikonde, where Sophie tended to him.

At about the same time as Antoine was regaling friends with tales of his recent travels while awaiting his chloroquine shot, sixteen-year-old Yombe Ngongo lay in Yambuku Hospital undergoing transfusions to counter her severe anemia. Nearby, twenty-five-year-old Lizenge Embale was recuperating from what seemed to be malaria, tended to by her husband, Ekombe Mongwa.

And over on the men's ward Angi Dobola was recovering from hernia surgery. The sixty-year-old villager from Yalaloo was watched closely by his wife, Sebo Dombe, who complained to the Sisters of exhaustion. Sebo was given vitamin injections, which helped her find the energy to cope with long, tense nights by her husband's post-op bedside.

On September 5 Antoine returned to the mission critically ill. He was vomiting and had acute diarrhea, leaving him so dehydrated that he had "ghost eyes," as the missionaries called them: deeply recessed, dark, glazed eyes surrounded by pale, parchmentlike skin stretched tightly over pronounced facial bones. His chest hurt, he had a terrible headache, fevers continued, he was deeply agitated and confused.

And he was bleeding. His nose bled, his gums bled, and there was blood in his diarrhea and vomitus.

The Sisters had no idea what was wrong with Antoine, nor did they

realize that he was not an isolated case. Yombe Ngongo had checked out of Yambuku Hospital on August 30, and was now fighting for her life at home, in the village of Yamisakolo. At the sixteen-year-old's side was her anxious nine-year-old sister, Euza, feeling her own first symptoms of headaches and fever.

And Sebo Dombe's exhaustion now exceeded the benefits of vitamin injections. Though her husband was recovering nicely from his hernia operation and the pair had returned home, Sebo was semi-delirious. She too was hemorrhaging blood. As was Lizenge Embale, who had returned to her home in Yaekenga in the beginning of September but was now struggling to stay alive. At her side, vomiting blood and bleeding from his eyes, was her husband, Ekombe Mongwa.

The Sisters knew only of Antoine's case, and they did everything they could to save their friend. The hospital had no sophisticated laboratory facilities to aid in diagnosis, so they could only guess what might be causing such horrendous things to happen to a human body—perhaps yellow fever, or typhus. They pumped Antoine full of antibiotics, chloroquine, vitamins, and intravenous fluid to offset his dehydration.

Nothing worked. On September 8, Mabalo ("Antoine") Lokela died. Unbeknownst to the Sisters, Yombe Ngongo died the day before in her village home. On September 9, her little sister, Euza, succumbed. That week Lizenge Embale and her husband, Ekombe, died in the hut in Yaekenga—again, the Sisters didn't know.

Antoine's funeral was well attended and, as was customary, his body was carefully prepared before burial by Sophie, his mother, Sophie's sister Gizi, and other women friends. By tradition readying a body for burial required evacuating all food and excreta, a procedure that was generally performed by bare-handed women.

In a matter of days Antoine's mother, Gizi, and Sophie were suffering the same ghastly disease; Sophie and Gizi survived, but Antoine's mother died on September 20, as did his mother-in-law, Ngbua, who had assisted in the funeral preparations. And though Sophie survived those hellish September days, her baby was stillborn—another hemorrhagic victim.

In all, twenty-one of Antoine's friends and family members got the disease; eighteen died.

Soon the hospital was full of people suffering with the new symptoms. Panic spread as village elders spoke of an illness, unlike anything ever seen before, that made people bleed to death. In Yambuku the Sisters were already close to the breaking point, not knowing the why, what, or how of the new disease.

The horror was magnified by the behavior of the many patients whose minds seemed to snap. Some tore off their clothing and ran out of the hospital, screaming incoherently. Others cried out to unseen visitors, or stared out of ghost eyes without recognizing wives, husbands, or children

at their sides. Word, and the disease, spread quickly to villages throughout the Bumba Zone. In some, the huts of the infected were burned by hysterical neighbors.

On September 12, Sister Béata developed the sudden fever, muscle aches, nausea, diarrhea, and bleeding gums that she and her fellow nurses now recognized only too well. Sisters Myriam and Edmonda prayed for a miracle and radioed urgent pleas for assistance.

Bumba Zone medical director Dr. Ngoi Mushola scoured the city of Bumba for petrol, finally arranging transport across the roughly fifty miles to Yambuku on September 15. What greeted Ngoi upon arrival was a horror that shook the provincial physician to his very soul. The Sisters and priests beseeched him to tell them what disease was claiming the lives and spirits of their parishioners. In desperation they begged him to help cure Sister Béata.

But Ngoi was every bit as helpless as the hapless clerics. With great care he gathered as much clinical information as possible, and on September 17 rushed back to Bumba in order to cable his report to authorities in Kinshasa.

Republique du Zaïre—Region of the Equator -S/Region of Mongala—Bumba Zone—Bumba Medical Service
Inquiry into alarming cases in the community of Yandongi, Bumba Zone, 15–17 September 1976.

I received an urgent call from Yambuku on September 15 from the medical assistant Masangaya Alola Nzanzu of Yambuku Hospital because of alarming cases in the community since September 5, 1976; I went to determine the reality of the situation.

Findings. The affliction is characterized by a high temperature around 39°C; frequent vomiting of black, digested blood, but of red blood in a few cases; diarrheal emissions initially sprinkled with blood, with only red blood near death; epistaxis [nosebleeds] now and then; retrosternal and abdominal pain and a state of stupor; prostration with heaviness in the joints; rapid evolution toward death after a period of about three days, from a state of general health.

Ngoi's report described the first case, that of Mabalo Lokela, and then listed twenty-six cases of the strange illness, giving the names of the patients, noting that fourteen had died, ten were still sick, and four had fled the hospital in terror, their whereabouts now unknown.

Eerily, Ngoi corrected his report just before sending it to Kinshasa to note that two individuals on his "ailing" list had died by the time he reached Bumba. He listed the treatments tried, without success, at Yambuku Hospital: aspirin, chloroquine, nivaquine, blood coagulants, calcium, cardiac stimulants, caffeine, camphor. And he noted that the hospital had used up all its antibiotic supplies.

Nothing helpful had been discovered in the Yambuku Hospital group's

microscopic studies of blood, urine, and stool samples, Ngoi noted. And he tactfully added that protective measures by the hospital to isolate patients with the disease "are not strict."

Warning that "there is already panic" in all the villages, Ngoi requested assistance from Kinshasa authorities.

He left Yambuku having recommended that the Sisters take three measures immediately: "(1) Hospitalize the cases. (2) Use public cemeteries.⁵ (3) Boil potable water."

What Ngoi had written, though he did not know it at the time, was the first historic description of a new disease. In clear, succinct, and, as time would show, largely accurate terms, Ngoi had described what would prove to be the second most lethal disease of the twentieth century.⁶

At five o'clock in the afternoon of September 19, Sister Béata died. The same day reports came into the mission of illnesses and deaths from the bizarre bleeding disease in over forty villages. By now, there was real danger of a mass exodus of hysterical villagers fleeing to nearby zones—and taking the disease with them. Through the missionary radio relay system, the Sisters sent more urgent pleas for assistance.

Federal authorities dispatched two professors from the National University of Zaïre to Yambuku: microbiologist Muyembe Tamfum Lintak and epidemiologist Omombo. They reached the mission on September 23, intending to conduct a six-day study of the problem, but cut their visit short and beat a hasty retreat from Yambuku after just twenty-four hours.

When they arrived at Yambuku Hospital, Muyembe and Omombo saw despair and horror everywhere they turned. Just hours before they arrived, twenty-six-year-old mission nurse Amane Ehumba had died of the disease, and anxieties among the Zairian hospital employees were at near-panic levels.

The professors first focused on a small child who was writhing in agony in a hospital crib. While they discussed what might be done, the child died before their eyes. The academics were shaken from their intellectualizing, and immediately set to work collecting blood and tissue samples from patients and cadavers, interviewing ailing patients and reviewing their medical charts.

As the professors commenced their research, Sister Myriam, who had nursed Sister Béata, was suddenly overcome by piercing headaches and fever. The fear among the mission staff was contagious.

Unfortunately, the academics hadn't taken Ngoi's field report seriously, and brought no protective gloves, masks, or gowns for their use during procedures that put them in contact with infected blood. Still, they worked around the clock, examining five blood samples for signs of malaria, parasites, or bacteria. They found nothing. When they performed autopsies, Muyembe and Omombo were aghast at the extensive damage inflicted by the disease, and removed liver samples to send to sophisticated laboratories for further analysis.

Sister Romana arrived during the day, having traveled all morning from the Lisala Mission, located in the zone to the southwest of Bumba. "I have come," she told the other Belgians, "to replace Sister Béata." The visiting nun set to work immediately, looking after the latest victims.

Among them was Sophie, still severely ill at that point, groaning in agony in her hospital bed. While the professors inspected the wards, their guide, nurse Sukato Manzomba, progressed from being mildly feverish to a life-threatening state. She began vomiting blood and passed into delirium. The stunned professors acceded to the missionaries' pleas and agreed to take Sister Myriam, Father Augustin (who had traveled with Antoine in northern Zaire and was running a high fever), and Sister Edmonda (as an accompanying nurse) back to Kinshasa for treatment.

The group traveled the muddy, bumpy road from Yambuku to Bumba in a Land-Rover, passing several villages along the way, and were airlifted the following day to Kinshasa aboard a Zairian Air Force transport jet. Left to their own devices at Kinshasa's N'djili Airport, inexplicably abandoned by the professors, the missionaries were forced to take a taxi to Ngaliema Hospital—Zaire's premier teaching facility.

From the moment she arrived it was obvious to the Ngaliema staff that Sister Myriam needed not a hospital bed, but a deathbed.

Because they had no idea what pathogen was producing the Sister's illness, the Ngaliema staff didn't know what precautions they should take. Sister Edmonda described the rapid spread of the disease inside Yambuku Hospital and volunteered to do the bulk of Sister Myriam's care. The ailing nun was placed in an isolated ward. A pretty young student nurse, Mayinga N'Seka, offered her assistance and Dr. Lusakumuna took charge of the case. Collectively they did what they could to ease Sister Myriam's suffering.

On September 30, despite their efforts, Sister Myriam died in the Kinshasa hospital.

II

Dr. William Close was in Wyoming at the time, negotiating the purchase of a ranch. For sixteen years he had lived in Kinshasa, serving as personal physician to President Mobutu Sese Seko and directing a nongovernmental medical development group called *Coopération Médicale Belge*. The American physician and his family⁷ had arrived in Zaire when Mobutu seemed a heroic, towering figure on the African landscape, a leader of postcolonial black Africa, and an inspiration to young idealists worldwide. But over the years Close witnessed Mobutu's transformation from a sort of Zairian George Washington to a tyrannical and corrupt despot enamored of the works of Machiavelli and surrounded by family and associates who treated Zaire's national bank as their personal cash register.

Grown cynical, Close was preparing for a new life in Wyoming when Dr. Ngwété Kikhela, Zaire's Minister of Health, called to ask Close to notify American authorities, requesting assistance. Close immediately contacted the Centers for Disease Control in Atlanta, apprising the agency of the situation and formally requesting laboratory support to determine the cause of the Yambuku outbreak.

Back at the mission, more of the hospital staff contracted the disease. Now ten of the seventeen employees were either dead or too sick to continue tending to patients. Following Muyembe's parting recommendations, Sister Genoveva closed the hospital to all but the remaining dying victims of the mysterious disease. Though she had no medical training and was one of the mission's teaching nuns, Sister Genoveva was forced to carry the onus: none of the Belgian medical personnel remained well enough to shoulder such responsibilities.

Sister Romana lay in one bed, vomiting blood, bleeding from her gums, suffering acute diarrhea, and groaning in delirium. The elderly Father Germain Lootens was similarly stricken, and none of the remaining Zairian nurses felt up to staffing the hospital without their supervision.

Lacking medical skills, Sisters Genoveva, Marcella, and Mariette turned to the only weapon in their armamentarium: prayer. For hours on end the grief-stricken nuns and the three remaining priests prayed over the sickbeds of their friends and colleagues, hoping their devout entreaties would bring a miracle.

Despite their prayers, Sister Romana died at noon on October 2. Word of her death, radioed by the Yambuku staff to the Lisala Mission, produced both tremendous grief and justifiable fear among her old friends. Just six hours later, Father Lootens also passed away and this threw the surviving Belgian missionaries into such despair and terror that a visiting team of Kinshasa scientists found the group virtually paralyzed by anxiety.

At Minister Ngwété's request, a team of medical experts had been assembled and flown to Bumba by the Zairian Air Force. From there they drove to Yambuku. The three-man team arrived shortly after the deaths of Sister Romana and Father Lootens. Ministry officials, notified of the deaths by relayed radio messages, ordered the area placed under strict quarantine and "cordons sanitaires" established around Yambuku.

Having no experience in such matters, Sister Genoveva took the order literally. She gathered up rolls of bandage gauze and strung them around the periphery of the mission and suspended signs from the "cordons" warning visitors to stay away. A large bell was hung at the mission entry, with a sign telling visitors to ring, leave their messages or food donations, and quickly withdraw.

Close explained the crisis to President Mobutu, who expressed concern about containing the epidemic, and put his personal Hercules C-130 transport jet at the disposal of the medical effort. He also ordered the entire Bumba Zone placed under strict isolation. All roadways, waterways, and

airfields in the region were placed under martial law, and the transport of goods and people in and out of the area came to a full stop within a week. The village elders of the Bumba Zone, recalling the smallpox epidemic of the 1960s, advised their people to remain housebound until the epidemic passed. Overnight all commerce, social life, schooling, and ritual gatherings ceased and the villages surrounding Yambuku looked like ghost towns.

Close helped gather medical supplies, rudimentary lab equipment, and other hospital essentials from warehouses and hospitals around Kinshasa, and these were loaded aboard Mobutu's jet and flown to Bumba.

Meanwhile, the three-man team of Kinshasa-based investigators, composed of Zairian health official Dr. Krubwa, Belgian medical mission director Dr. Jean-François Ruppot, and French medical mission chief Dr. Gilbert Raffier, did their best to comfort the extremely upset Yambuku missionaries. They gathered more blood and tissue samples, examined medical records, and toured local villages. Though the scientists still had little solace to offer, the missionaries were greatly relieved, and radioed gratitude to Bumba for the supplies and physicians.

At about the same time, Paul Brès received word that another strange epidemic was unfolding in a town called Maridi in the grasslands of southern Sudan. Information was scarce, and authorities in the Sudanese capital of Khartoum had no radio contact with that impoverished and distant region to the south. Still, Brès and other experts in the virus branch of WHO thought—from their distant Geneva vantage point—that the Sudanese accounts bore a remarkable resemblance to those from Yambuku. He urged Khartoum to immediately send blood and tissue samples from Maridi patients.

But it was no simple matter for a doctor in Khartoum to make his way to Sudan's southernmost provinces, gather blood samples, store the precious fluids in containers that would protect their contents from the intense desert heat, and make his way back to Khartoum. In addition to the usual—and monumental—logistic obstacles to such a trek, whoever went faced the even more towering blockade of politics.

But the mysterious epidemic was occurring in one of the country's three most southerly provinces, where the people lived and believed as they had since before the Nubians were enslaved by Egypt's Pharaohs. Speaking a variety of ancient Bantu languages, the southern Sudanese were animists who believed all living things, as well as the sun, water, wind, and weather, had a spiritual character. The manipulation of these often unpredictable and fickle spirits and gods was the province of fate: wise sorcerers knew how best to cajole the spirits to support their ends or repel evil spirits that produced illness, death, and misfortune. The southerners lived in small, temporary villages, were often nomadic, had a high rate of illiteracy, and could not be expected to be found in any particular locale at any specific time.

In 1969 Sudan had a military coup d'état. A Muslim-led civilian government backed by the military was installed, and the nation teetered on the edge of civil war, splitting the Muslim north and the Christian, animist south until 1972. Then a semblance of peace took hold when a constitutional agreement was reached, providing the three southern provinces with a fair degree of self-rule. The autonomous region was only nominally connected to the Khartoum-based infrastructure, and it was rare indeed that a Ministry of Health official from the north would be asked, or would agree, to intercede in medical problems to the south.

Still, Brès and other Geneva officials insisted on pushing past the political obstacles to discover what was going on in Maridi. Their greatest fear was that the epidemics of Yambuku and Maridi were one and the same, representing a vast super-lethal disaster spanning an area of about 1,000 square miles in at least two nations.

Blood samples, collected in Maridi and shipped over several days' time to Khartoum, finally reached Geneva. They were in poor condition, but WHO immediately sent them on for analysis in laboratories in the United States and the U.K.⁸

III

WHO enlisted high-security laboratories all over the world in the effort. It wasn't hard, really: everybody wanted a piece of the action. Though the best guess was that the disease was caused by the yellow fever virus, the outbreaks were something new, intellectually exciting. Throughout October and November blood and tissue samples from disease victims in Yambuku, Kinshasa, and Sudan were sent to laboratories in the United States (Centers for Disease Control, Atlanta), the U.K. (the Microbiological Research Establishment, Porton Down, Salisbury), Belgium (the University of Anvers and the Prince Leopold Institute of Tropical Medicine), West Germany (Bernard Nocht Institute for Naval and Tropical Diseases), and France (special pathogens branch of the Pasteur Institute).

On October 11 the Pasteur Institute's director of overseas research, Claude Hannon, told Pierre Sureau to go to Roissy Airport to retrieve a package containing blood samples from Kinshasa, adding that he should "consider the packet's contents dangerous." The perilous shipment was, however, misrouted to Paris's Percy Hospital, passing through many hands before Sureau was able to track it down.

When hours later he obtained the curious box and opened it at his lab bench, Sureau found a thermos flask containing several Vacutainer tubes of blood surrounded by dry ice—a commonly used freezing protective layer. Tucked among the tubes was a note from Dr. G. Raffier of the French Embassy in Kinshasa, dated October 10, 1976:

Sir, the enclosed tubes contain blood samples collected at a mission October 4 to 9 on patients and illness contacts at the hospital of the Catholic Mission of Yambuku, Bumba Zone, Equatorial Region of the Republic of Zaire. This village of Yambuku and another close neighbor, Yandongi, are currently seized by a deadly epidemic of indeterminant nature. It began September 5. It is now in regression (10-9-76). . . . The first assumptions were that the region was hit by yellow fever (but four of the dead Belgian missionaries were vaccinated) or typhoid fever. The first analysis done at the Institute of Tropical Medicine (IMT) of Anvers eliminated yellow fever and typhoid; a virus not seen before was isolated at Anvers.⁹ We have not yet received results of a liver biopsy sent to Dakar. A diagnostic assumption of Lassa has been advanced, but not proven to date. The fresh blood samples have been preserved on dry ice.¹⁰

Sureau knew Lassa could be terribly dangerous—he'd certainly heard of Jordi Casals's near-fatal infection. But he had no reason to believe the suspected virus could be airborne. He placed the nine tubes in a rack atop a sterile lab table, opened the first, and dabbed a sample on filter paper.

The implications of such casual behavior would be obvious a few weeks later. One of the tubes contained Sister Edmonda's blood.

But as Sureau looked at the tubes his only thought was: "What shall I do first? Electron microscopy? Antibody complementarity assays?"

He was smoking a cigarette, mulling it over, when the phone rang. Paul Brès, chief of the Viral Diseases Branch of WHO, was calling from Geneva.

"Pierre, have you received the suspected blood samples from Zaire?" he asked.

"Yes, Paul, I got them this morning."

In an urgent tone Brès stressed that the samples were "highly infectious and must be studied in a maximum-security laboratory. They must be sent on immediately to the CDC in Atlanta. Don't open them!"

"Too late, Paul, I already did," Sureau said, anxiously glancing at the nine neatly lined-up tubes.

Brès instructed Sureau to repackage the tubes immediately and ship them by overnight plane to Atlanta. Then Brès asked Sureau whether he would serve as the official WHO consultant for the mysterious epidemic. Sureau agreed without hesitation and left the following day for a briefing in Geneva. He would be in Kinshasa within thirty-six hours.

As requested, Sureau sent the nine test tubes to Karl Johnson at the CDC, and enclosed his own note summarizing the contents of Raffier's letter and information from Paul Brès, noting that he had repacked the samples in more secure containers.

"I am leaving this evening for Kinshasa on a mission for WHO," Sureau concluded, "to participate on the ground in research. My instructions are to send to the CDC clinical samples I collect."

A week earlier, Peter Piot, then only twenty-seven years old, was completing his virology postdoctoral research at Anvers when the first myste-

rious blood samples had arrived from Zaire. With Piot were Flemish biochemist Guido van der Gröen, Bolivian physician René Delgadillo, and their boss, Stefan Pattyn. The group looked at the odd blue thermos that reached them via Brazzaville and discussed rumors they'd read about in the Dutch press of, as van der Gröen put it, "something weird in Zaire, involving Belgian missionaries."

An accompanying note from WHO authorities in Brazzaville indicated that yellow fever was suspected.

"Well, that's not very dangerous. Not in the lab anyway," Piot reasoned. He blithely pulled on a pair of latex gloves and, without further precautions, opened the thermos. Inside he found a soup of melted ice, an illegible, water-soaked note from somebody in Zaire, an intact test tube, and another one, broken into pieces, its contents mixed into the watery soup. Piot, under the watchful eyes of his colleagues, removed the intact tube, setting it out on the tabletop in their lab inside a mundane research facility in the city of Antwerp.

Years later, while eating a luncheon salad of *jambon* and *fromage* in a noisy Rive Gauche café in Paris, Piot would explain that he had been "young, foolish, and fearless" and that it wasn't until well after Christmas in 1976 that he stopped to reflect on the tremendous dangers he had faced. Only then did he allow himself to finally experience fear.

But in the first week of October all the ambitious young Belgian saw when he looked at the samples was a wondrous mystery. He and van der Gröen first prepared samples for standard yellow fever antibody tests, using antibodies that would react with the contents if the virus was present. Negative. He repeated the yellow fever test. Still negative. Then he tried typhoid antibody. Also negative.

But van der Gröen confirmed that whatever was in that odd blue thermos from Zaire was quite deadly by putting droplets from the intact test tube into larger tubes containing so-called Vero monkey cells. Within eleven days, the Vero cells were dead, and when van der Gröen withdrew liquid from the dead Vero tubes and put it in tubes full of fresh Vero cells, they too died within ten to eleven days.

The laboratory in which this work was done had no special security or containment facilities, no fancy hoods to draw dangerous bugs up into ducts, away from scientists' mouths. Indeed, the Belgians labored under conditions no more sophisticated or secure than might be found in a typical high school biology lab.

Their folly would prove striking in retrospect, and all concerned would later express astonishment that they suffered no ill consequences from such frivolous disregard of the potential hazards of the microbes.

Indeed, three days into their research, the much older Pattyn removed a rack full of incubating infected Vero cells for examination. He tilted the rack to get a clearer look, and a tube slid out, crashing to the laboratory floor.

Delgadillo and van der Gröen stared in panic at the wet floor, the Bolivian noting that liquid had splashed on his shoes. Van der Gröen, spotting his Bolivian colleague's anxious glances at his shoes, looked at his feet as well: fluid splattered his wing tips in deadly little beads. Delgadillo and van der Gröen exchanged worried glances.

After a few moments, Pattyn suggested that van der Gröen "clean it up," and left the laboratory. With gloved hands, van der Gröen and Delgadillo gingerly wiped up the floor and their shoes, then liberally spread disinfectant around the facility.

Shortly after the Belgian group's Vero cell studies confirmed the dangers of the mysterious Zairian microbes, their government began questioning the wisdom of continuing the Antwerp research effort. They were instructed to pass the samples on to higher-security laboratories outside Belgium. Van der Gröen convinced Pattyn to save one small sample, reasoning that it should be used as a backup, in case the primary samples were damaged or lost in shipment to Porton Down.

Having ruled out the easy answers, Piot eagerly prepared the sample for analysis under an electron microscope. He gasped as he stared at the strange viruses; they were shaped like question marks.

"This is a new virus! It's something we have never seen before," he exclaimed, feeling the thrill of discovery. The virus was a long wormlike tube that coiled at one end and left the other extended. Piot imagined that when he asked, "What is this?" the viruses simply answered back: "????"

Thoroughly committed to solving the mystery of the "???? viruses," Piot was disappointed when WHO telexed on October 7 that the group should cease all research immediately, saying, "Investigations indicate this may be Marburg." Piot packed the last sample, wrote up his findings, and, as per WHO instructions, shipped the lot off to Karl Johnson at CDC. He was intrigued by the diagnosis and wanted to go to the scene of the epidemic to see for himself.

The usually shy Piot uncharacteristically marched over to the Belgian Ministry of Development Cooperation and argued his case. "We have to be there," he said. "There are missionaries, Belgian missionaries who died."

He didn't need to underscore Belgium's unique relationship with Zaire. In 1876 the European power had begun to colonize and brutalize the Congo, as it was called. Now, almost exactly a hundred years since King Leopold II declared the Congo a part of the Belgian Empire, authorities in Brussels were at pains to rid their country of its guilty legacy. On the other hand, the Belgian government was also acutely aware of the risks inherent in offending Mobutu or his government. It was an extremely delicate situation to place in the hands of a twenty-seven-year-old, politically naïve post-doctoral student.

"All right," Piot was told, "You can go. We will only fund one week. And you're representing the Belgian government."

Carrying the only suit he owned, he may have been prepared to meet officials in Kinshasa and travel around Zaire for a week. But he was woefully ill equipped for what would become a three-month stay in a tropical rain forest during the Zairian summer.

Dr. Stefan Pattyn, before sending his samples on to England's maximum-security laboratory in Porton Down, had completed studies in laboratory mice, which showed that the virus was quite lethal to rodents. He had also compared the mystery virus to Lassa, concluding that "it was probably some other arbovirus," not the West African killer. Now he too departed for Zaire, leaving van der Gröen behind to monitor the health of the accident-exposed members of the Antwerp laboratory.

On October 14, Patricia Webb and Fred Murphy completed their first round of studies of the mystery virus, working in the CDC's maximum-security laboratory. In 1976 the lab was designated a P3 facility. A P1 facility was a basic laboratory such as could be found lining the hallways of university science departments; a P2 facility had a slightly higher level of security with entry limited to trained, authorized personnel and actual research work performed under hoods that sucked air away from the experiment, up a ventilator duct, and past scrubbers that disinfected the air with ultraviolet light and microscopically gridded filters; a P3 lab was state of the art in high-security research. For Webb, working in a P3 lab meant passing through a series of guarded locked doors, presenting her security pass for entry. She would then shower with disinfectant soap and don a set of head-to-toe protective clothing, gauze face mask, double latex gloves, and radiation badge to monitor her levels of exposure to isotopes occasionally used in such research. She would then pass through two more air locks lined with microbe-killing ultraviolet lights.

Once inside the inner core, Webb might enter either the laboratory or the animal room. Both rooms were pressurized; all air was forced in past microscopic filters and sucked back out rapidly through several additional layers of filters, ultraviolet lights, high heat sources, and chemical scrubbers.

A further layer of protection was provided by glove boxes: more sophisticated versions of the portable box Karl Johnson jury-rigged for his studies of the Machupo virus in Bolivia. All Webb's samples from Zaire were stored in deep freezers overnight; small amounts were thawed during the day and analyzed inside the boxes. Webb would thrust her already double-gloved hands into a larger set of thick rubber gloves that were permanently installed in the clear-plastic front wall of the hooded box. She would then try, with three cumbersome layers of rubber over her hands, to manipulate test tubes, pipettes, petri dishes, and the like. It was slow-going, arduous work that often proved physically exhausting.

Harder still was the animal work. To find a mysterious microbe, it was necessary to inject samples into mice, guinea pigs, hamsters, and monkeys, all of which were also kept in large glove boxes. The animals didn't sit

still in the grasp of bulky gloved hands, and injections were often a test of wills between scientist and guinea pig.

In such a setting the greatest risks to the scientists were accidents, such as cutting oneself with a broken contaminated test tube or receiving an animal bite. Webb had never cut herself, but she had been bitten several times by monkeys that attacked her approaching gloved hands. Fortunately, those monkeys were part of Webb's Machupo research, and, having already suffered the disease, she was immune.

These Zairian samples, however, tested negative for Machupo, and Webb was acutely aware of the need to work with slow, cautious deliberation. It was not her style, really. When Patricia Webb graduated in 1950 from Tulane University Medical School in New Orleans, only eight other women were in her class. In those days a handful of women were given the opportunity to matriculate into a field dominated by males. Unlike most of her fellow students, Webb never planned to spend her life in a profitable practice giving middle-class kids antibiotics for strep throat and monitoring the blood pressures of obese patients.

Since childhood in England Webb had been fascinated with stories of India, Pakistan, and China and saw medicine as a sort of universal passport.

It hadn't gotten her to India yet, but through medicine and research virology she had already seen Malaysia, Panama, Bolivia, California, Louisiana, Georgia, and the Washington-Baltimore area. But now she found herself locked inside an artificial environment day after day.

The further Webb got into her research, however, the more obvious it became that the CDC needed to deploy a team immediately for fieldwork on the ground in Yambuku. With the approval of her CDC seniors, Webb began amassing further information and planning her fieldwork.

She asked the CDC's personnel office to find a staff scientist with three key qualifications: fluency in French, strong African experience, and training in epidemiology. The name Joel Breman popped up.

Breman had spent six years in Africa since completing his medical studies—two years in Guinea and four in Burkina Faso. He had been part of D. A. Henderson's successful campaign to eradicate smallpox, and he was fluent in African-dialect French. But Webb was a little anxious when she noted he was technically an EIS (the CDC's Epidemic Intelligence Service) trainee.

In late September, when the CDC's Lyle Conrad contacted Breman in Michigan, the epidemiologist was knee-deep in another investigation—of Swine Flu. Conrad asked if the EIS trainee would like “one hell of an assignment. It's in Africa, it's a little frightening. Something has killed just about every villager in the area. You'd be gone about a week.”

Having spent six years in tropical Africa, Breman knew nothing got done in one week. And he didn't like the sound of this particular mystery. Nevertheless, over the next three weeks the tall, bearded scientist talked

almost daily over the phone with Webb, getting a sense of the excitement and fear surrounding the Zaire outbreak. For her part, Webb soon grew used to Breman's long-winded, often cliché-packed ramblings. Beneath his occasionally incoherent conversational style lay a sharp intellect that Webb recognized and planned to push to its limits in Yambuku.

On October 10, Webb and her co-worker, Fred Murphy, officially informed WHO that “the illness is caused by a virus that resembles Marburg (Marburg-like), that the epidemics are probably caused in Zaire and Sudan by an etiological agent that is similar but represents a new immunotype that is in the family of Marburg.”¹²

Webb's Marburg speculation prompted an international escalation in scientific security. Thereafter the CDC and Porton Down—the world's most secure labs in 1976—received virtually all samples of the mystery agent.

At Porton Down it was Geoffrey Platt who handled most of the mystery virus research. His lab wasn't exactly an American-standard P3 facility; rather it was a uniquely English mix of P3 and P2 elements. Because the British antivivisection movement was quite militant in its opposition to the use of laboratory animals, security in the form of controlling access to Porton Down was very high. Indeed, most British citizens had no idea where the lab was located or what it did.

Since 1964 Platt had worked at Porton Down with dangerous viruses, particularly Lassa, taking precautions to protect himself, though the microbes were not kept safely inside glove boxes, as was done at the CDC. The rooms were, indeed, pressurized, and the air was decontaminated before being released into the English countryside, but Platt's personal protection was limited to a cloth surgical gown, a double layer of latex gloves, and an old World War II-era gas mask. Though the respirator had been thoroughly tested for its effectiveness in protecting British soldiers from combat gases, it had never been proven that the mask filtered out viruses. Nevertheless, the handful of Porton Down scientists and technicians who worked with super-lethal microbes were limited to using the cumbersome, often hot masks that always seemed to cloud up in the midst of delicate procedures, usually leaving researchers with headaches by the end of the day.

Every night after work, Platt would scrub his mask with Lysol and spray it with formalin disinfectant.

Though mindful of the risks, and very careful in his work, Platt knew there were dangers, especially when working with an unknown, Marburg-like killer.

“Care is absolutely essential,” Platt told his colleagues, warning that nobody should enter his lab or animal care area unless absolutely necessary—at least, not until Platt knew what lurked in those test tubes. “You've got to realize you're working in some danger and be able to accept that. It's not good if you're going to go home at night and not be able to sleep.”

Platt had no way of knowing that in just three weeks he himself would lose a great deal of sleep worrying about his own chances of survival.

Platt's work on the Sudan samples prompted WHO to release, on October 15, the following urgent bulletin:

Haemorrhagic Fever of Viral Origin. Between July and September 1976, it was observed in the region spanning N'zara to Maridi, in southern Sudan, sporadic cases of fever with haemorrhagic manifestations. It is thought that the first cases occurred among agricultural families. During the last week of September, the situation worsened considerably, 30 of 42 cases occurred in Maridi hospital among members of the staff; it is thought the disease was spread directly from one person to another. By October 9, 137 cases, 59 deaths, were reported for the region comprising N'zara, Maridi and Lirangu. The epidemic has caused panic on the local level. . . .

The report closed with these words: "Samples from Sudan and Zaire have revealed the presence of a new virus, morphologically similar to Marburg, but antigenically different."

Well before WHO officially released that report, the agency had confirmed from three labs (CDC, Anvers, Porton Down) that a deadly new virus had been discovered, and had initiated an international effort to try to stop the epidemics in Zaire and Sudan, identify the virus, and determine how and why it had appeared. In a matter of days, what began as a problem in a missionary hospital would involve investigators and military personnel from eight countries, several international organizations, the foreign ministries of at least ten nations and the entire health apparatus of Zaire. Almost overnight, events would snowball into an effort necessitating over 500 skilled investigators, and mobilizing the resources of numerous European and American institutions, all at an indirect cost of over \$10 million.

Direct costs for the Yambuku investigation alone would exceed \$1 million.

IV

The snowball effect began modestly enough on October 13, with Pierre Sureau's arrival in Kinshasa. The Pasteur Institute virologist represented WHO for the duration of the epidemic, and had the task of assisting Zairian authorities in any way possible. Sureau's first meeting was with Minister Ngwété Kikhela, who informed the French scientist that it would be several days before transport to Yambuku could be arranged. Such delays were to become a major component of this investigation, one that was constantly plagued not only by the mysterious virus but also by logistical nightmares aggravated by national panic. All commercial flights to Bumba had ceased as a result of the regional quarantine. That left only Zairian Air Force

transport to the region, but terrified pilots were rebelling against orders to enter the Bumba Zone.

Though his hopes of getting an immediate look at the Yambuku epidemic were thwarted, the spry, middle-aged French doctor was able to see a case of the disease on his first day in Zaire. Having nursed her dear friend Sister Myriam, Sister Edmonda now lay dying in Ngaliema Hospital's Pavilion 5 isolation ward. Sureau found her semi-delirious, severely dehydrated from days of diarrhea, feeble, anorexic, feverish, completely drained of energy; yet, surprisingly, unafraid.

"She knows what is coming. She has seen it before with Sister Myriam and all the cases in Yambuku. Yet she is calm," Sureau noted, with considerable amazement.

Sister Edmonda thanked the doctor for his attention and "the good conversation," and clutched the hand of an elderly Kinshasa nun, Sister Donatienne. Sureau took a blood sample and departed.

That night Sister Edmonda died.

"My God!" Sureau exclaimed. "That virus is fast!"

The following morning, October 14, Sureau returned to Ngaliema and discovered that a new patient had arrived. Student nurse Mayinga N'Seka, who had tended to both Sister Myriam and Sister Edmonda, was developing the first symptoms of the mysterious disease at about the time Sister Edmonda died. Two days earlier, Mayinga had spent hours in a general administrative office awaiting transit papers for overseas study, where she had contact with numerous strangers and officials. She then took a taxi to Mama Yemo Hospital, where she sat in a crowded waiting room, waiting for someone to treat her fever, headache, and muscle pains.

Sureau and Ngaliema doctors quickly determined that Mayinga had the Yambuku disease, and transferred her to Ngaliema's Pavilion 5 isolation ward. Concern and rumors started to spread through the streets of Kinshasa.

Meanwhile, WHO remained convinced the culprit could still be a strain of Marburg disease, so Sureau and Close contacted the South African team that had treated the Australian tourists a year earlier, asking for antiserum. The politics of such a request were dicey, and necessarily involved notifying the Mobutu government, South Africa's apartheid leaders, and the embassies of France and the United States. Though it violated Zaire's ban on relations with South Africa, all government representatives eventually agreed, for the sake of young Mayinga and the people of Yambuku, to allow Dr. Margaretha Isaacson to fly up from Johannesburg, Marburg antiserum in hand.

"It's our only hope," Sureau told Zairian officials.

Talking incessantly, Isaacson hit the ground running and approached medicine like a field commander, ordering the Ngaliema medical troops about and bringing instant order to a scene that had been dangerously close to chaos. She and Sureau gave Mayinga the Marburg antiserum, and then the South African sat down with Zairian doctors to plan the transformation

of Pavilion 5 into a bona fide isolation ward. The Zairian medical staff, which had been in a state of extreme agitation ever since their colleague fell ill, was thrilled to see the "space suits" Isaacson brought from South Africa. Soon the entire staff of Pavilion 5 worked in head-to-toe white suits that had clear-plastic face coverings and respirators. The suits proved horrendously uncomfortable in the steamy Kinshasa heat, but the Ngaliema staff was enthusiastic about the protection.

They were far less enthusiastic about Isaacson's recommendation, supported by the Zairian Health Ministry, that the entire Pavilion 5 staff be placed under quarantine. Health Minister Ngwété made it clear his greatest concern was the possible spread of the Yambuku virus from Ngaliema Hospital into the streets of Kinshasa, endangering the 2 million residents of the capital. For nearly a month, a half dozen staff members would be confined to Pavilions 5 and 2 of Ngaliema Hospital, forbidden to leave the confines of the area to see their families.

Officials tracked down 37 people with whom Mayinga had shared meals or close contact in the days prior to her illness, placing all the unfortunate men, women, and children inside Pavilion 2 for twenty-one days of quarantine. One quarantined woman would give birth during her stay, and all the staff and isolated civilians would fight day-to-day personal battles against boredom, fear, and fatigue. In addition, 274 people who had had recent contact with the Pavilion-bound individuals were found, blood-tested, and kept under close surveillance.

Fortunately, no further cases of the Yambuku disease would develop in Kinshasa.

Years later, reflecting on the extreme precautions taken at Ngaliema Hospital, Isaacson would say that "perhaps we were overdoing things a little bit," but "we could not afford doing less than the maximum precautions that were available. We could not do it ethically, we could not do it scientifically."

Constantly abandoning all precautions—much to Isaacson's consternation—Sureau never wore a mask, and often spent long periods of time at Mayinga's bedside, chain-smoking cigarettes and dispensing calming conversation. Despite huge cultural and generational gaps, the student nurse and the physician became close, and Sureau often voiced his increasingly urgent hope that the Marburg antiserum would save his new friend. Mayinga herself was far from optimistic. Having seen the agony the Sisters had endured, she was frankly terrified.

"Dr. Isaacson is here," Sureau told Mayinga gently. "She is one of the greatest experts in the world on Marburg. You are in very good hands. Have faith."

Later, as he carefully prepared samples of Mayinga's blood for shipment to Pat Webb's CDC laboratory, Sureau could barely contain his excitement about the coming trip to Yambuku.

"For the community of arbovirologists, this is one of the greatest events

in contemporary epidemiology," he noted in his diary. "No one of us would pass up such an opportunity for passionate study. Personally, I am delighted to be in this place, and to participate in such an adventure."

Sureau's enthusiasm was tempered the following day, however, when Mayinga's condition deteriorated. Isaacson decided to try a second dose of the precious antiserum, and Sureau again comforted Mayinga by telling her that Isaacson was an expert. But by then the French and South African physicians knew the truth: whatever was infecting Mayinga was *not* the Marburg virus.

On October 18, six weeks after the Yambuku epidemic began, the core of what would that day be dubbed the International Commission arrived. Loaded down with enormous crates of sophisticated laboratory equipment, a plastic isolator for research, state-of-the-art microscopes and protective gear came the Americans: Karl Johnson and Joel Breman of the CDC Special Pathogens Branch. Still in her maximum-security Atlanta laboratory, Patricia Webb was steaming mad. Just days before her planned departure, CDC director David Sencer had decided the job was "too big and leadership of the mission was awarded not to the woman, but to her husband."

The Machupo legends had preceded Johnson to Kinshasa, and Sureau's admiration for the man who discovered and survived Bolivian hemorrhagic fever was undisguised. Now a middle-aged veteran of dozens of CDC investigations, Johnson carried himself with a reasoned calm that inspired confidence in the men around him. He would be the foreman for an oft-adventuristic bunch of disease cowboys. Johnson, Breman, and Sureau became instant friends, and everyone, including the Zairois, deferred to Johnson's leadership.

By the end of the day the core of the International Commission was in place, and its first meeting convened (tensions eased by ample quantities of French wine) at five o'clock in the evening. October 18, chaired by Minister Ngwété. Present were six Zairois, including Omombo, who had made a twenty-four-hour visit to the Yambuku Mission and had dramatically raised levels of anxiety in Kinshasa government circles. Representing WHO were Sureau, smallpox expert René Collas, and two Zaire-based European physicians. The five-man Belgian contingent included Stefan Pattyn and Pierre Piot. One South African (Isaacson) and one official French representative (Gilbert Raffier) were present. And Americans Johnson, Close, and Breman were joined by Dr. John Kennedy of the U.S. Embassy. In coming weeks this core group would guide nearly all Yambuku-related activities, operate in several languages, crossing often difficult political and cultural boundaries, each professional adhering to his or her designated responsibilities, and all answerable to the acerbic, often flat-out outrageous Johnson.

Niceties and introductions taken care of, Johnson swiftly guided the multilingual group through its marching orders, delegating responsibilities and laying out a strategy for attack that drew heavily from experiences

Machupo and Lassa. Breman was put in charge of epidemiology investigations: doing the detective work necessary to determine who was spreading the disease, how, and with what clinical results. Together with Belgian Jean-François Ruppel, Piot, Zairian scientist André Koth, and Sureau, Breman was told to prepare for immediate departure for Yambuku.

Johnson reminded the group that the virus they were dealing with was extraordinarily dangerous, and using colorful language peppered with obscenities, ordered everyone to take their temperature twice a day, follow to the letter Isaacson's recommendations for protection, and always work in teams.

That night Piot, Sureau, and Breman prepared, each in his own way, for the next day's journey to Bumba. Young Piot, who had never before set foot outside Europe, was anxious to get out of the wedding suit his government had instructed him to wear, and see the infamous nightlife of Kinshasa. All night long the Belgian doctor strolled the streets of the city, chattering incessantly with the friendly Zairois, listening to the *ramba* rhythms in nightclubs, and sampling local drinks and delicacies.

"This is wonderful!" Piot exclaimed to local team members who showed him the town. "What an exciting place."

He didn't want to sleep, or think about the epidemic. Piot arrived at the airport the following morning groggy and caffeine-sobered. Though sleepy, he grew increasingly alert as the time for the team's departure drew closer.

Sureau was also excited as he sat in the President's plane awaiting takeoff.

He had to admit, however, that he was "a little scared of the unknown," and had been in no mood to party all night with the young Belgian. Instead, Sureau had paid another visit to Mayinga, finding her condition further deteriorated. The young student nurse was emotionally overwrought. He reviewed virus containment and protection procedures with Isaacson. And from her got a copy of *Marburg Virus Disease* by Martini and Siebert,¹² which he was now trying to read aboard the Hercules jet.

Breman, feeling the dull disorientation of jet lag, had spent the evening working out logistics with Johnson and Ruppel and making sure the proper equipment found its way into the plane's cargo bay.

After a three-hour flight the jet landed on Bumba's tiny airstrip. The terrified Air Force pilots left the engines running and ordered the scientists to get out as quickly as possible. Piot drove their Land-Rover, packed with supplies, out of the cargo hold, and hadn't even parked it before the panicky pilots began to taxi for takeoff.

Piot could feel the eyes of hundreds of people upon them as he inspected the Land-Rover. The airstrip was lined many rows deep with anxious-looking people.

"My God, the entire town must be here," he whispered to Sureau.

"They've been under quarantine for days," Breman reminded his col-

leagues. "They're fed up, and they're scared. I imagine they think we're going to perform some kind of miracle."

That night the scientific team shared the hospitality of Catholic missionaries in Bumba, who brought them up to date on radio messages from Yambuku. Bumba physicians Ngoi Mushola, Zayemba Tshiana, and Makuta briefed the foreigners on their clinical observations, noting that the epidemic had spread to several villages around Yambuku.

Sureau passed the final hours before retiring that night in quiet discussion with the grief-stricken priests of Bumba. Joel and Peter, however, were too high on adrenaline and curiosity to sip vermouth with aging clerics, so they went to a folk music festival at the local cathedral.

The following morning the group looked in on a handful of mystery disease patients at the Bumba hospital, and, fortuitously, met Dr. Massamba Matondo, chief physician for the neighboring Lisala province. Massamba, a careful doctor with an instinct for epidemiology, had already toured the epidemic area and he told Sureau the disease was claiming residents of at least forty-four villages in a fifty-mile radius around Yambuku.

With Massamba and Bumba missionary Father Germain Moke, the scientists made their journey to Yambuku later that morning in two Land-Rovers. The fifty-mile drive took all afternoon. Rarely could the frustrated drivers gain enough speed on the bumpy muddy roads to get out of second gear.

More than three hours later, they reached Yambuku.

They turned off the engines and immediately felt the sad silence of the place. Gone were the noise and activity of typical Zairian villages, the long lines of chattering women and children waiting for vaccinations, the vendors selling their wares. Indeed, gone were the people, altogether.

Piot spotted Sister Genoveva's odd white gauze "cordons sanitaires" strung about the mission, and a sign in French that said: "Do not enter; to call the Sisters ring the bell." As he approached the bell three nuns came running out of one of the buildings, calling, "Don't come near! You're going to die! You will die! Stay away!"

Recognizing their Flemish accents, Piot jumped over the "cordons" and shouted greetings in their shared native tongue. Overwhelmed at hearing Flemish, the nuns broke down, sobbing. Sureau, Ruppel, and Breman quickly joined Piot in his efforts to comfort the women, and the Sisters were pleased that Jean-François had, as promised, returned to their devastated outpost. As tensions and emotions eased, the scientists unloaded their equipment and followed the Sisters to the school. Closed since the fourth week of the epidemic, the barren classrooms became their temporary home.

Over dinner and plenty of wine the Catholic teachers and clerics poured out their stories for hours on end, while the visitors patiently listened, asked gentle questions, and occasionally jotted down notes. Sister Marcella,

who had been keeping logs of the dead, presented her grim lists to Sureau.

Speaking in a deliberate monotone, which seemed to help her keep her emotions in check, Sister Marcella explained that in the past month 38 of the 300 residents and employees of Yambuku had died, including all the missionary nurses, four out of six Zairian nurses, one of the three padres, and one of two hospital laundry workers. Then she gave the scientists a sobering list of villagers afflicted. The visitors realized they would have to go to every single village, conducting a house-to-house investigation. No other approach would do.

Sister Marcella also volunteered that the first unusual medical problems at the hospital may have occurred in August, when three women died in close succession on the obstetrics ward. They had bled to death after giving birth. The Sister had checked hospital records for the same time periods in 1975 and found no such cases, and she was unable to tease out of the general hospital records cases of anything similar to the strange new disease prior to August 1976.

"It is new," she told them. "It is definitely something new."

V

While the exhausted scientists slept on the hard floors of the Yambuku school, Mayinga lost consciousness in Ngaliema's Pavilion 5. And the commission members argued late into the Kinshasa night about contingency procedures for handling infected team members.

Joe McCormick had just started unpacking his hundreds of crates of laboratory supplies for Lassa research when he received a cable from the CDC in Atlanta, instructing him to temporarily abandon the lab outside Kenema, Sierra Leone, and make his way as quickly as possible to Kinshasa. The cable stated that his familiarity with northern Zaire, coupled with his epidemiology skills, made him indispensable. He was instructed to bring with him the portable glove-box lab he and Johnson had rigged up in Atlanta just weeks earlier, and other equipment that was needed at Ngaliema Hospital for testing and screening blood samples and preparing antisera against the mysterious disease.

Just a few months earlier, having heard of McCormick's exploits in Brazil, Johnson had snagged Joe one day in the CDC hallway.

"I'd like to send you to Sierra Leone," Johnson said, "to figure out just how widespread Lassa really is."

McCormick hadn't been in West Africa, and the Lassa puzzle sounded "damned interesting," so in March 1976 he packed and prepared to set up a one-man Lassa research station in Sierra Leone. Just before he left, McCormick and Johnson rigged a glove-box contraption similar to the one Karl had used in Bolivia, and Joe gathered enough equipment to study the virus safely under even the most primitive conditions.

Within a week he had his Lassa research station: a small building 200 miles from the capital, outside the town of Kenema. It contained two chairs and his cases from Atlanta. He'd just uncrated Johnson's portable laboratory when the cable arrived from Kinshasa.

McCormick knew there was no easy way to get from Freetown, Sierra Leone, to Kinshasa: virtually all flights between African countries were both notoriously expensive and unreliable; nearly all went from one African country to another via the formerly colonial European countries.

For three days McCormick bluffed, bullied, and bribed his way onto airplanes and through customs in Freetown, Abidjan, and, finally, Kinshasa. He completed the 2,000-mile journey with all equipment crates, remarkably, intact. At Kinshasa's N'djili Airport he sprinkled a little Kiswahili and Otetela in with his French, and eventually convinced customs and immigration officials to let his crates into the country, unopened, undamaged, and unexamined.

Meanwhile, the scientific team awoke with the Yambuku dawn, relayed an abbreviated version of Sister Marcella's reports by radio to Bumba (from where they were ultimately relayed to Kinshasa), breakfasted, and set out in different directions in four teams to inspect the villages. Piot and Sureau were teamed up, and Sister Marcella, ecstatic to be outside the mission after so many days of quarantine, acted as their guide.

"We must limit the numbers of us who are exposed to this virus until we determine how infectious it is," Sureau told the group, instructing that only he and Piot should draw blood.

The trio first arrived in Yalikonde, close by Yambuku, where they quickly learned how to gain the trust of the fearful villagers. A working pattern developed that was repeated in ten villages that day. It would begin with an amble about the middle of the village, during which time the leading elder of the community would introduce himself. The group would discuss the weather for a while, until the elder invited them to share some *arak*.

"This stuff is pure methanol," Piot whispered.

"Drink!" Sureau commanded.

After the *arak* burn had made its way down their throats and into their stomachs, the Yalikonde elder introduced the white men to Lisangi Mohago, a twenty-five-year-old man who had been struggling with the disease for six days. The visitors examined Lisangi, who was far too weak to protest, and drew a blood sample.

Everywhere the group went they noticed the people had taken remarkably wise measures to stop the epidemic's spread. Roadblocks were staffed around the clock near village entries, virtually all traffic on the Ebola and Zaire rivers had come to a halt, the ailing villagers and their families were kept under quarantine, bodies were buried some distance away from the houses, and there was little movement of people between communities.

"These people have really got their act together," Piot told Sureau, who was also impressed by the steps taken.

In one village about ten miles from Yambuku, Piot and Sureau found a husband and wife lying side by side in their hut, both in the final throes of the disease. Pierre took blood from the husband while Peter prepared the wife's arm.

Sureau shifted his weight to face the wife, found a vein, and inserted his syringe. As he released the tourniquet and watched blood slowly fill the tube, the husband let out a deep groan and died. The wife cried out, Sureau quickly withdrew his needle, and she rolled over to embrace her dead husband.

Shaken, they stepped out into the sweltering sun and whispered anxiously. If the husband had died while Sureau was taking his blood, the villagers might have attacked the men, accusing them of responsibility or, worse, of homicide. As it was, many villagers were taken aback when the tall white men—especially Breman and Piot, who both stood over six feet—donned goggles, rubber gloves, and surgical masks before entering the homes of the infected.

For their part, the Europeans and the American had no idea whether these modest precautions were adequate to protect them from what they now understood firsthand was a particularly horrible disease. Breman was a bit anxious that villagers might be offended by his protective gear, but he was also, as the blunt American put it, "scared shitless."

"I'm no Marlboro Man, and I don't mind admitting I'm really frightened. As, I think, we all should be," Breman told his colleagues, who vigorously nodded their concurrence with his sentiments.

When the team members reunited at the mission after their first long and emotionally exhausting day in the villages, they compared notes and agreed that the epidemic had taken a terrible toll—in some cases claiming entire families—but the worst of it seemed to have passed. Breman, in particular, was relieved to see that initial accounts saying entire villages had been exterminated by the virus were gross exaggerations. Without knowing its cause or cure, the people had wisely taken many proper measures to slow the virus's spread. The scientists humbly agreed that their scientific expertise had not been necessary to arrest the epidemic.

But it would require the best their collective talents could muster to solve the mysteries of where the strange virus came from, how it was spread, and how best to prevent its resurgence.

That evening as they relaxed with more mission wine, layered atop several rounds of village *arak*, a day-old radio communication reached them from Kinshasa, via Bumba.

"Mayinga died late the night of October 20," it stated flatly.

Sureau was devastated, as were the Sisters, who felt profound gratitude for the student nurse's courage in tending to Sisters Edmonda and Myriam.

"What we are dealing with is a virus like Marburg, but *more* pathogenic. A super-Marburg. I don't feel alarmed, but I do feel a sense of disagreeable

uncertainty. Who will be the next victim among the caregivers? Sister Donatienne? . . . Margaretha or me? The incubation time is usually eight days! How many more victims will there be in the villages? What can be done to stop this epidemic?" Sureau asked.

The others looked at Sureau in sad agreement, for he was voicing thoughts shared by all.

Though Sureau had clung to the increasingly dubious hypothesis that the epidemic was caused by some sort of Marburg virus—probably in a spirit of hopefulness on Mayinga's behalf—Breman had no such illusions. Breman had been on the phone with Pat Webb at least twice a day for the three weeks prior to his arrival in Kinshasa. He knew precisely what Webb had discovered, and he carried with him eight-by-ten microscope photos of the enemy. As he wandered about the villages, Joel would hold up the "???? virus" pictures of fuzzy, curled, wormlike microbes and explain to the Zairis that this new entity was the cause of their suffering.

The trained epidemiologist of the group, Breman laid out a symptomatic definition of the Yambuku disease that the four teams should use as they scoured villages for cases.

That night, Sureau radioed Bumba to tell Kinshasa that first surveys showed 46 villages were affected, with over 350 deaths.

For the next few days the scientists worked in Yambuku, Bumba, and the villages in between, having no way to communicate either with Karl Johnson in Kinshasa or with one another once they split off daily to investigate separate villages. Sureau and Breman occasionally received garbled messages about helicopters due to arrive with more experts and better equipment. When the copters failed to arrive, they simply assumed the messages were mixed up.

It broke Breman's heart to watch the nuns "communicate" with their ancient ham radio equipment. Every day at a designated time a Sister would put her ear to the decades-old speaker, turn on the radio, and listen through horrendous static for the voice of the monsignor in Lisala. One by one, he would call out the name of each mission in northern Zaire and in this crude manner the network of missionaries would order supplies and share important news.

Though he had hooked up newer equipment, the overall system was so primitive that the American-made side-band radios made little difference. There remained no way to communicate directly with Kinshasa, and all communications were subject to the problems inherent in the child's game of Telephone, in which one person passes a sentence on to another, and another, until after a tenfold relay the message bears little resemblance to the original. U.S. Embassy officials told Johnson that setting up a sophisticated communications system connecting Yambuku, Bumba, Kinshasa, and Atlanta "would entail several million dollars and a twenty-four-hour aircraft relay system." In his usual insouciant fashion, Johnson had words

with the officials, but Breman, having had his fill of U.S. State Department types elsewhere in Africa, suggested Karl not waste his energy on the bureaucrats.

Meanwhile, Karl Johnson was trying his best to outmaneuver other logistic nightmares created by the Zairian Armed Forces (which didn't want to fly anywhere near Yambuku), the embassies of the United States and France, and a host of international political issues. He needed a top entomologist or ecologist—somebody who could search, as Merl Kuns had in Bolivia, for the insects or animals that carried the disease. After casting its net far and wide, WHO decided to send French Dr. Max Germain, who worked in the agency's Brazzaville office.

Finally, Johnson needed to get a team further out, way up to Sudan, to figure out how the epidemics of Yambuku and Maridi were connected. For that job Johnson knew exactly whom he wanted: "This one's for Joe," he said, anticipating McCormick's imminent arrival.

McCormick landed in Kinshasa on October 23, the same day the CDC's David Heymann cabled word that a NASA space capsule had successfully been transported from Houston, where it was staffed and ready to receive any WHO team members unlucky enough to catch the virus. Also ready at the Frankfurt Airport in Germany was a USAF C-131 transport jet with an Apollo space capsule aboard—the same space capsule that Henry Kissinger had offered two years earlier for use in airlifting Lassa-infected *Mandrella* from Nigeria to Hamburg.

That day Johnson got an update from Geneva on the Sudanese epidemic. A team of investigators had been selected, comprised of ten Sudanese doctors, Irishman David Simpson, France's Paul Brès, and the CDC's Don Francis. The investigators were instructed to rendezvous immediately in Khartoum and from there make their way south to Maridi.

Johnson also wanted a top-flight lab worker in Kinshasa right away—someone who could improvise and create a diagnostic laboratory out of the meager facilities available. Pattyn recommended van der Gröen, who immediately flew to Zaire loaded down with essential supplies. Key among his gear were microscope slides he had carefully coated with infected Vero cells. Though they were fixed with acetone, van der Gröen had no way of knowing whether or not those slides were covered with contagious organisms.

"It doesn't matter," he told himself. "I'll make sure I'm the only one exposed to these things. But I must have them. There is no other way to diagnose infection."

His plan was to diagnose infections by putting patients' blood samples on the microscope slides, waiting a while, then rinsing the slides. If patients were infected, they would make antibodies against the mysterious microbe that would latch on to the infected Vero cells. He then planned to mix fluorescein—a molecule that glows under ultraviolet light—with monkey antihuman antibodies. When the fluorescent antibodies were coated onto

the microscope slides, they would cling to the human antibody-attached Vero cells. And van der Gröen planned to simply flash ultraviolet light at his slides to see which people had infected blood. Though the method had been in use for Lassa since Jordi Casals's days at the Rockefeller Foundation, van der Gröen had never tried the immunofluorescence technique, and hoped that he would be able to perform professionally in the epidemic pressure cooker.

On arrival at Kinshasa's airport, van der Gröen was greeted by Belgian diplomats who ushered his supplies through customs and whisked the bewildered scientist off into the night. Van der Gröen's initiation into the Zairian investigation began with a harrowing midnight drive on the highway to Kinshasa, which, as was typical, was marked by several near-collisions with cars and trucks that careened at high speeds without using their headlights. The Zairis believed that they saved fuel by shunning headlight use. As Ruppel briefed van der Gröen on the Yambuku epidemic, the terrified Belgian stared agape out the windshield as one oncoming vehicle after another suddenly loomed out of the darkness, coming within inches of their car, which was driven by a Zairis who deftly dodged all the nearly invisible cars and trucks.

At that moment nobody could have convinced van der Gröen that within a few days such sights would seem blasé.

After a night of restless sleep, van der Gröen arose early to meet his new boss, Karl Johnson. Watching Johnson shout commands, always laced with florid language, van der Gröen thought the American "a very peculiar man." But during his first of the daily morning epidemic meetings, van der Gröen witnessed Johnson's uncanny ability to coordinate a multilingual, multicultural team of individual egos, creating a single, well-oiled antimicrobe machine. As had all those who arrived before, van der Gröen instantly admired Johnson and accepted his leadership without question. Johnson ordered the young Belgian to go to Ngaliema Hospital and create a modern laboratory—immediately.

Late that night Johnson came by, holding up some blood samples that Sureau and Piot had sent down from Yambuku. The men uncased Johnson's glove box, placed it atop the wooden table, and set to work. Van der Gröen had never worked with his hands inserted inside heavy stationary gloves, and he found the process terribly cumbersome and frustrating. Johnson taught the Belgian tricks that he had learned nearly two decades earlier in Bolivia, and the pair were soon toiling smoothly as a team.

Sweat poured off van der Gröen, and every step of the procedure performed in the glove box seemed to take ten times longer than it would atop his Antwerp lab bench. But by two in the morning, he had completed each step of the immunofluorescence process. All that remained was the ultraviolet light microscope examination to see whether or not the serum from Yambuku was infected with the mystery microbe. For that, the pair needed a completely dark room.

Van der Gröen hauled a small table into the bathroom, used the toilet as his seat, and turned off the electric lights.

He switched on his ultraviolet microscope, and with Johnson holding his breath in anticipation, van der Gröen put his eye to the lens.

"*Comme les étoiles!*" he exclaimed. "Like twinkling stars . . . in a dark night, surrounded by red cells. Look, Karl, the cells containing the virus are bright, glowing, fluorescent masses."

Johnson took the toilet seat and peered down the lens. It was three-thirty in the morning, but the men were too excited to sleep. The serum they were looking at came from Sophie in Yambuku, who had survived the disease. Finally they had a way to test who was infected, and to find people who had been infected but successfully fought off the microbe without developing detectable disease. They also now had a way to test whether a particular person's blood contained potentially lifesaving antibodies.

That morning Pierre Sureau awoke in Bumba feeling feverish, unsettled. He and Piot spent the day arguing with the Zairian Armed Forces for transport of equipment from Kinshasa.

As he sat on a veranda overlooking the Bumba Mission, Sureau contemplated what he had learned so far: The disease was clearly deadly, and most victims died within a week. It had taken a huge toll at Yambuku Hospital, and left the surviving nuns and priests nearly incapacitated with grief.

Sipping a cocktail, Sureau contemplated the most awkward finding: the condition of Yambuku Mission Hospital. The previous day he, Breman, and Piot had examined the now empty facility, its medical records, and equipment. When they entered the compound, Sureau had been appalled. The sterilization facilities were abominable, the surgical equipment positively antique, and the linen—though washed—was often covered with old blood stains.

Yet when he examined the medical records, he found no telltale link between people who had undergone surgery in the antiquated facility and those who got the disease. He wiped fever sweat off his brow, and couldn't shake the uneasy feeling that the starting point for the epidemic was—somehow—that well-intended but fatally primitive hospital.

With the contemplative Sureau now in Bumba, awaiting an armed forces plane to Kinshasa, were Piot, other team members, Sophie, and Sukato. As the surviving wife of Yambuku's first victim—the index case, in epidemiology parlance—Antoine, Sophie had antibodies of incalculable value. Yambuku nurse Sukato was the only member of the mission's medical staff who had survived infection and illness. These two in coming days would donate many units of blood, from which would be derived a tiny vial of antiserum of inestimable value.

By October 24 Sureau's secret fever disappeared. He told no one about his illness: Johnson had insisted from the beginning that team members take their temperature twice a day and immediately report fevers to Kin-

shasa headquarters. Sureau chose to disobey, convinced that whatever he had was not the Yambuku disease.

Fortunately, he was correct.

Sureau was still feeling hot under the collar, however, because the long-awaited plane from Kinshasa hadn't arrived. Johnson sent word that President Mobutu was out of the country, in Switzerland, and in his absence the government was nearly paralyzed. No one else dared order the armed forces to fly into the Bumba Zone.

Sureau and Piot were worried that their samples would go bad in the tropical heat if these delays continued. They made more dry ice for their storage thermos and kept their fingers crossed.

At last on October 27 the Zairian Air Force arrived in the form of a C-130 transport, loaded with lumber and supplies for the construction of a villa for Captain General Bumba, a powerful commandant. The pilots refused to turn off their engines and ordered the group to board immediately.

The pilots grew positively enraged when they spotted the unexpected passengers, Sophie and Sukato.

Ruppel explained the two were very important people: survivors of the epidemic. The appalled pilots swore that nobody infected with the disease could board their aircraft, nor would they allow samples of contaminated blood and tissue on the plane.

A truce was reached: the group could board the plane, but none of them could enter the cabin for any reason. Squeezed in among the commandant's building materials, the passengers did their best to get comfortable during the two-hour flight to Kinshasa. For Sophie and Sukato, both novice air passengers, it was a terrifying experience.

The following morning, October 28, Piot nervously strolled the Kinshasa streets. Like Sureau before him, Piot was running a high fever. Worse yet, he had uncontrollable diarrhea and felt distinctly nauseated. Fearing Johnson would order him airlifted out of the country, Piot hid his ailment from the others, deliberately shunned team members, and searched on his own for dysentery treatments.

Meanwhile, both Sureau and Breman told Johnson that they privately believed the source of most of the fatal cases in Yambuku's epidemic was the hospital. Breman described in detail his eerie stroll through the hospital, and showed Karl two syringes he had delicately removed from a pan of water in the outpatient clinic.

"I'll bet these are infected," Breman said, noting that the clinic issued only five syringes to its nurses each morning. They were used and reused on the 300 to 600 patients who required medical attention each day.

When Johnson suggested it might be a bit dicey to point an accusatory finger at four now deceased Catholic missionaries, Breman said, "The villagers clearly understood the hospital was the source. Long before it was closed, the people voted with their feet. They ran away. That place was almost empty when it closed."

Johnson decided to put Breman in charge of a second survey team, responsible for designing a way to test Joel's hypothesis. The plan was to conduct a major epidemiological investigation with nearly all the International Commission directly involved. The first step would require returning a small team to Yambuku to recruit and train a staff of local Zairois, particularly those who had survived the disease and were presumably immune. Johnson warned Breman, however, that one of the locally recruited Machupo investigators in San Joaquín had mistakenly thought a past ailment was Bolivian hemorrhagic fever. It was not, and Einar Dorado had paid for the error with his life.

"Be damned careful," Johnson said.

On October 27 the commission released its first official account of events in Yambuku to foreign embassies in Kinshasa; the following day embassy officials passed the information on to the international press corps. It was a bland statement, conservatively designed to cast a sense of routine around a crisis that had rendered some team members patently terrified.¹³ Still, two scientists, a Zairois and an American, who read the report, requested permission to drop out of the investigation. The American had made it as far as Geneva before turning back.¹⁴

VI

On October 31, Sureau, Germain, McCormick, and recently arrived Belgian researcher Simon van Nieuwenhove gathered on the military strip at N'djili Airport at four-thirty in the morning. Now accustomed to the anxieties of the Zairian Air Force, the group had triple-confirmed the flight plans. Their cargo was impressive: two fully equipped Land-Rovers complete with a three-week supply of diesel fuel, food (C rations), and water. The plan was for the group to fly up to Bumba, where they would leave off Sureau and Germain, then proceed further north, to Isiro.

For McCormick and van Nieuwenhove, Isiro would be just a first stop on long separate journeys. McCormick was destined for Maridi, van Nieuwenhove was assigned to search the remote southernmost expanse between Zaire and Sudan for additional pockets of the epidemic.

Of course, despite all their prior confirmations, the scientists were told the planes weren't quite ready for takeoff, and at five-thirty in the morning the pilots were scrambling to cannibalize parts from other planes. Finally, five hours later, the reluctant pilots—having exhausted all reasonable dodges—were forced to concede defeat to the scientists, and the C-130 took off for Bumba.

The pilots landed in Bumba and, as always, kept their engines running while Max and Pierre unloaded the cargo and waved goodbye to their friends. Then they took McCormick and van Nieuwenhove to Isiro some 300 miles further north near the Sudanese frontier. The two men drove

their well-stocked Land-Rovers off the C-130, shook hands, and headed in opposite directions.

In Isiro (known in colonial days as Old Stanleyville), McCormick hunted for information and some additional supplies, quickly discovering there was little of either to be had. After years of central government corruption, Zaire's most remote areas were bereft of all but local trade, and such "luxury" items as toilet paper, matches, and batteries had long since disappeared.

Information was equally scarce, and McCormick found that the lack of trade activity had slowed the flow of traffic and communication between Zaire's various northern zones to a mere trickle. Surprisingly few people in the region seemed aware of the Yambuku epidemic, and nobody could recall a case of anything resembling that hemorrhagic disease.

As McCormick headed northeast toward the Sudanese border his language skills began to fail him; the more remote the area, the fewer people spoke French, or Otetela, or any other Bantu tongue of which McCormick had a passing knowledge. Soon he found himself in villages not visited by a motorized vehicle in months, even years. And he, a bearded white man, would use an assortment of hand signals and languages to try to find out if anybody in the community had recently suffered an unusual disease. It was hard going, and all too often Joe found himself trying to make sense of conversations that, for example, began in Azandi, were translated into Lingala, and then conveyed to him in French. Information was, at best, muddled.

The closer he got to the Sudanese frontier, the less obvious were the roads. Several times he bailed his Land-Rover out of a river, or plowed through yards of six-foot-tall elephant grass praying the road would reappear on the other side. He was making his way through an area that experienced torrential rains nine months out of the year, and was perpetually mud-laden.

At the border he discovered an Italian Catholic mission so removed from its Roman headquarters that the priests were living on five-year-old flour and the "protein" provided by the insects that infested their meager supplies. Elated at seeing a visitor from so far away, the priests were eager to assist McCormick and insisted he share in their sparse food reserves.

The priests told McCormick there were rumors of an epidemic around the Sudanese village of N'zara, located some sixty miles further northeast. Joe told the priests he had no visa or travel papers.

"That is no problem," they said. "We will take care of it."

After a night's rest, McCormick was introduced to the chief of a Zairian village adjacent to the border. At the priests' request, the chief signed a letter that formally asked his counterpart on the Sudanese side of the border to admit McCormick into the country. Arriving at the much-anticipated border, Joe found two posts, atop which rested a long stick. Between the border posts lay the road, now narrowed to a mud footpath and bearing no

signs of recent vehicular traffic. A handful of obviously hungry soldiers sat on their haunches around the site; they greeted McCormick's arrival as a source of grand gossip and entertainment, breaking up an otherwise miserably monotonous day.

When Joe finally reached N'zara he sent a relayed radio signal to Karl Johnson to assure his friend in Kinshasa that he had arrived safely and could confirm there was an epidemic afoot. To accomplish such a seemingly simple task: McCormick first sent a ham radio signal to the Italian missionaries back at the Zaire border. They relayed the message to a pilot flying a missionary twin-engine plane. He ascended to sufficient altitude to be able to send an unblocked signal down the length of Zaire, where it came out of the speaker of Johnson's single side-band radio. With such a complex system it was obvious that the message had to be short and sweet: the details would have to await Joe's return to Bumba.

For three weeks McCormick slept in the Land-Rover by night and interviewed epidemic victims and survivors by day. It became obvious that few people traveled between the N'zara area and Yambuku, a distance of over 400 miles.

By the time Joe arrived the worst of the N'zara outbreak was past, and there were no more active cases in the clinic. For several days he questioned residents of N'zara and the outlying villages, and collected blood samples. Satisfied that the epidemic was under control, his supplies dangerously low, McCormick prepared to return to Zaire. But first, with a hint of mischief, Joe wrote a note to his CDC colleague Don Francis. McCormick knew Francis was heading up an official WHO team that was trying to make its way to N'zara from Khartoum.

Before he left, McCormick put the note in a box and left it with a town leader instructed to "give the container to the white man who will come soon from Khartoum."

McCormick had no idea that Francis and his team were trapped in Khartoum, hostage to terrified pilots who were refusing to fly and government bureaucrats uncertain about providing open access to the Europeans and Americans. It would be several days before the WHO team would reach the area. In the meantime, McCormick's container, pregnant with information, waited in the hot N'zara sun.

In American holiday terms, McCormick left Isiro on Halloween and returned to the Bumha Zone the day before Thanksgiving, having been virtually incommunicado the entire time.

Much had happened in his absence. A full-scale epidemiological survey of all the villages surrounding the Yambuku Mission had been conducted, involving most of the International Commission members. For nearly two weeks, the team, augmented by dozens of trained local volunteers, surveyed over 550 villages, interviewed 34,000 families, and took blood samples from 442 people in the hardest-hit communities. In addition, team members gathered a sampling of local insects and animals to test for viral infection.¹⁵

And on November 6, Zaire's Minister of Health, Ngwété, issued an international report summarizing findings to date: 358 cases of the viral disease had occurred, 325 were fatal. That was an astonishing lethality rate of 90.7 percent.

Ngwété said all tests in labs throughout the world proved that "this agent is a new virus."

"The name 'Ebola,' after a little river in the region where the disease first appeared, is proposed for this virus," Ngwété concluded.¹⁶

Somehow, having a name for the culprit had brought new energy and focus to the Yambuku investigation, and the fears of the scientists receded with repetition of the word "Ebola." After a while, "Ebola" sounded almost routine, like "measles" or "polio."

That sense of relative calm evaporated when, several days later, the International Commission learned that Geoffrey Platt had contracted Ebola disease in England.

For nearly a month Platt had toiled with caution and deliberation in his laboratory at Porton Down, trying to learn quickly as much as possible about the Sudan strain of the Ebola virus. On the morning of November 5 he was working in the Toxic Animals Wing of Porton Down, passing Ebola samples from one guinea pig to another to see if the virulence of the virus was diminished as it went through successive generations of animals. As always, he was wearing a respirator, protective lab clothes, and three layers of latex gloves.

His hand slipped.

The syringe containing Ebola-infected guinea pig blood jammed into the tip of his thumb, just above the nail.

Horried, Platt was seized by panic, and for some time—he had no idea whether it was seconds or minutes—he stared at the thumb and saw his mortality.

"Hurry, get a grip on yourself," he said, ripping off the three sets of gloves and squeezing hard at his punctured thumb tip.

"Bleed, damn it! Bleed," he muttered, but no blood appeared. He dashed out to the next chamber and shoved his hand into a disinfectant tank. For two minutes he held his digit submerged, praying against all biological probability that no virus had actually passed into his thumb; or the disinfectant was getting drawn up into the microns-wide pore created by the needle, killing the virus; or the accident hadn't actually happened at all. He could feel his heart pounding hard against his chest, and feared the adrenaline-propelled organ was all too efficiently pumping Ebola virus throughout his body.¹⁷

He slowly withdrew his hand from the vat, daubed it with a towel, and used a magnifying lens to search for the needle puncture site. He saw no sign of it.

Carefully following lab exiting procedures, Platt left the Toxic Animals Wing and reported to the Laboratory Safety Office, where he was examined

briefly, given a thermometer, and sent home with instructions to report any sudden rise in his temperature.

For six days Platt paced the floors of his lab and house, losing sleep for the first time in his many years of working with lethal viruses. His wife, Eileen, did her best to shield their two preadolescent children from the growing anxiety shared by their parents.

At midnight on November 11, Platt's temperature suddenly jumped, and he felt the chills of a fever. The following morning he reported to the Porton Down safety office. By then his fever was over 100°F, and the staff was very worried, not only on Platt's behalf but also for everyone at the laboratory with whom he'd had contact. They immediately took a blood sample from Platt, examining a droplet under an electron microscope.

The dreaded "???? virus" was there.

Platt donned a respirator to protect others from his virus, and a special ambulance staffed by volunteer drivers and guided by a police escort took the English scientist to North London's Coppetts Wood Hospital. While Platt was placed inside a new Trexler negative-pressure plastic isolator, the 160 other patients then in the hospital were hastily packed off to alternative medical facilities.

For forty-nine days Platt languished inside his plastic environment, which was, in turn, inside an otherwise empty hospital. The large medical staff that tended to him, led by Dr. Ronald Emond, was placed under quarantine. And throughout the first week of Platt's life-struggle, he was entirely cut off from family and friends.

Meanwhile, Eileen and the kids were under house quarantine, forced to constantly check their own temperatures, and terrified that Geoffrey would die.

The British government's reaction to Platt's illness was rapid and severe. Porton Down was immediately shut down, all its employees sent home and placed under surveillance. Several friends of the Platt family were also put under home quarantine. Over a month's time some £200,000 was spent by the U.K. government to compensate employees for lost work time, relocate Coppetts Wood hospital patients, and monitor over 300 people for possible Ebola infection.

Meanwhile, Platt suffered most of the symptoms seen among Ebola victims in Zaire and Sudan. His care, however, bore no resemblance to that available to the people of Yambuku.

As Platt's fever climbed to over 104°F, his hair fell out and he passed blood in his stools and vomitus. Dr. Emond's team attacked the virus with every weapon available. Recently isolated human interferon—a crucial chemical of the immune system—was injected into Platt twice a day in large doses (3 million units). The ailing scientist was placed on intravenous feedings, carefully selected to balance his diarrhea-disrupted electrolytes. When *Candida* fungal infections appeared in his throat, Platt got amphi-

tericin B lozenges. Every fluctuation in his vital signs and blood and urine chemistry were monitored closely.

And forty-seven hours after his fever began, Platt was infused with Sophie's plasma, flown in from Kinshasa.

Following the Ebola plasma treatment Platt's condition worsened; his fever spiked again, he was extremely nauseated, his bowel was incontinent, his joints all ached, and he was very weak. Most alarming to Emond was Platt's mental state. The bright scientist was losing his memory, couldn't concentrate long enough to finish reading a sentence and seemed disoriented.

Platt was indeed very confused.

"Why am I in this plastic tent?" he wondered. "Who are these people looking at me? Where am I? Why can't I read? Did I used to be able to read?"

By November 20, nine days into his illness, Platt began to shed his confusion (along with dead skin and hair), and shortly before Christmas the British government was pleased to conclude that nobody else at Porton Down or in the Platt family had become infected.

England, it seemed, was spared.

News of Platt's illness came to Yambuku on November 12, hitting the commission members very hard. Morale plummeted and collective fear rose. Johnson sensed that the anxiety could be impairing the team's efforts. Certainly Max Germain, whose job was collecting wild, possibly infected animals, was on the verge of panic, and Breman had warned Karl that several team members had asked about the reliability of emergency evacuation plans for flying infected scientists to Johannesburg. Johnson tried to reassure the researchers, but he knew every movement the commission had made since the day it formed had been slowed or impaired by logistic problems.

By November 9, Sureau, having personally searched 21 villages, identified 136 fatal Ebola cases, and mapped the complex relationships of all the dead, recovered, and well people in those villages, was ready to leave. Of all the foreigners flown into Zaire during the epidemic, Sureau had been at it the longest. He was burned out, and both he and Johnson felt the epidemic was over. Sureau began his long journey home.

But the mystery of Ebola was far from solved.

On November 16, McCormick cruised into Yambuku, greeting the commission members with startling news.

"Guys," he said, "what we have here is two totally separate outbreaks. There is no relationship between what's going on here and what's happening in N'zara, except they both happen to be Ebola virus."

Johnson looked at Joe as if he had just watched his protégé's mind snap. Breman shook his head in disbelief. And young Piot grinned, thinking, "Jeez, this guy's got balls!"

McCormick explained to his disbelieving colleagues that travel between the two areas was so arduous, and the cultural gaps so great, that people simply didn't go back and forth.

"There's no way the Yambuku epidemic could get to N'zara or vice versa unless some infected person traveled those roads. And I can tell you, guys, my Land-Rover was the first vehicle on those so-called roads in months . . . maybe years."

Furthermore, he argued, there were no Ebola cases in the villages between N'zara and the Bumba Zone, and the Sudanese epidemic seemed less severe; more people appeared to survive Ebola in N'zara. McCormick's theories were dismissed out of hand by most commission members, and official WHO accounts of the 1976 outbreaks implied there was some as yet undiscovered link between the two epidemics.¹⁸

Joe stubbornly insisted, however, that despite what seemed coincidence on an unnaturally profound scale, the two epidemics were entirely separate events. He would not abandon that belief with the passage of time, and years later would provide irrefutable proof that Nature had, indeed, rolled an incredibly bizarre set of snake eyes.¹⁹

VII

While McCormick wrote up his Sudanese findings for the commission, epidemiology investigations continued in the Yambuku area. Piot was left alone full-time in Yambuku, while other commission members combed neighboring areas. A few days after Joe's return, Piot got a radio message from Johnson, telling him a Zairian Air Force helicopter would arrive shortly to bring him back to Bumba for a meeting with "U.S. Embassy officials." Piot protested: why should he, a Belgian, fly back to brief a group of Americans?

"Look, Peter, they want to see firsthand what's going on. Don't argue with me. Just get your butt on that copter," Johnson said.

Piot got off the radio grumbling about the "sick tourism" of the U.S. Embassy and CIA interests, but reluctantly prepared to meet the Zairian helicopter.

As he paced about the mission, the skies suddenly darkened and he could tell a storm was coming. Out of the blackened sky came the Puma helicopter. Without shutting off its engines, the pilot opened his cockpit window and called out to Piot. When Piot asked the pilot about the safety of flying such a large cumbersome helicopter in a storm, he smelled the familiar scent of Zairian beer on the pilot's answering breath.

"*Pas de problème*," the pilot insisted.

Piot asked a few more questions, studied the pilots, and concluded the two of them were drunk.

"The hell with it," Piot said. "I'm not going to that meeting." As he

waved off the pilots, a Yambuku villager ran up crying, "Doctor, please! I've never been in the air before. If you are not going, may I take your place?"

Piot shrugged, helped the young man into the helicopter, and waved the aircraft on its way.

Two days later a somber Johnson radioed Piot with bad news, telling him that the drunken pilots had crashed the helicopter. Everybody on board died, and a hunter found the wreckage in the jungle southwest of Yambuku.

Piot listened in disbelief as Johnson went on to explain that the Zairian Air Force was holding Piot personally responsible for the deaths.

"They're saying you sabotaged the helicopter because you're some kind of Belgian colonialist," Johnson continued. "And they're insisting you have to go out there, get those bodies and perform autopsies. There's no ifs, ands, or buts on this one, Peter. You have to do it. The entire research effort could be shut down in an instant if the Zairian military tells Mobutu we're a bunch of CIA agents or something."

Shaken and angry, Piot jumped in his Land-Rover and drove as fast as roads would allow to Bumba. There, he was assigned a detail of prisoners from the local jail, who worked all night under Piot's direction, making three coffins. The next morning Piot and the prisoners were flown by bitterly angry Zairian Air Force pilots to a plantation on the edge of the jungle area in which the hunter had spotted the wreckage. With the prisoners in a line behind him hauling the coffins and supplies, Piot cut a path through the rain forest. Whatever image the sight of Piot, the coffins, and the prisoners conjured for local villagers, it was obviously one of great interest. As the grim group cut its way deeper into the jungle, it was joined by clusters of the curious. Eventually, over a hundred people trailed the coffin bearers.

The wind first told them when they had reached their destination, for it carried the stench of three human bodies that had literally cooked for four sweltering days in the equatorial jungle. Piot, standing a foot taller than most of his companions, peered ahead, trying to catch a glimpse of the helicopter. The jungle canopy was so dense that little sunlight penetrated it. Still unable to see the copter, Piot paused and pulled a respirator out of his knapsack.

At the ghastly sight of the wreckage, all the prisoners screamed in horror and ran away. When he turned to look straight at the wreckage, Piot had to struggle hard to hold back a wave of nausea. The bodies had bloated in the humid heat, their eyes bulged, insects crawled over their taut skin, and the stench was overpowering. Fighting back his disgust, Piot forced himself to walk up to the first body, formaldehyde sprayer in hand, to ready it for the coffin.

It was the young villager. Piot swayed, feeling suddenly dizzy. "This should have been me," he thought. "I should have been in that seat, instead of this poor fellow."

He looked at the villagers, at the bodies, and called out, "The shoes! The shoes! Whoever helps me gets their shoes!"

A cluster of boys ran forward, helped Piot stuff the bodies into their tight coffins, removed the shoes, and then carried the horrendous burdens—unlidded to compensate for the swelling—out of the jungle.

When they reached the plantation Piot found the military pilots busily pursuing the business of alcohol consumption. They had refused to assist in the removal of the bodies, and looked on Piot with undisguised contempt.

"Here are your colleagues," Piot said, pointing at the gruesome coffins.

The pilots gulped down more beer and *arak*, ordered Piot to put the bodies in the aircraft, and made it clear that they were in no mood to argue with a white man from Belgium. For half an hour Piot sat white-knuckled, barely able to breathe, clutching the armrests of his helicopter seat as the belligerent, inebriated pilots maneuvered their copter and its macabre cargo to Bumba. When they landed, Piot was beside himself with rage and fear; he called the bluff of Bumba military officers, refused to perform the autopsies they had demanded, and declared, "You have your bodies, I've done my part, the hell with you!"

Peter Piot staggered off into Bumba, feeling more emotionally wretched than he had previously imagined was possible. For the first time in his life, Piot set off, with determination, to get drunk.

After a couple of beers, he felt tears pressing against his eyelids, and thought again of the poor villager who had perished in his place. He bought drinks for anybody in the bar who would hear his story, and soon the modest establishment was packed with thirsty ears.

After a couple of rounds, he heard someone greet him in Flemish, looked up, and saw a white man covered in road dust. Simon van Nieuwenhove introduced himself, explained that he had just returned from a four-week tour of the wilds in search of Ebola cases, and asked if he might join in the revelry.

The two men shared sagas, beers, and emotions, and developed an instant friendship that would bond them like brothers for the rest of their lives.

In the following days Piot and van Nieuwenhove talked for hours, trying to make sense both of the strange epidemic and of its impact on their lives. Piot's backgrounds in medicine and virology had served him well, but the twenty-seven-year-old Belgian had enough humility to recognize that he knew nothing about developing countries, and even less about epidemiology. He had developed a strong admiration for the multifaceted skills of the Americans—Bremann, Johnson, and McCormick. And he decided to ask Johnson to recommend him for epidemiology studies at the CDC.

Like so many other members of the International Commission, Piot was discovering that the relatively brief Yambuku experience was completely changing his life. It would be some time before he would discover the effect his African encounter was having back home on his wife, Margarethe. And on van der Gröen's wife, Dina. Unbeknownst to the men, the Belgian

government had informed Dina and Margarethe that "there had been a deadly helicopter crash involving Belgian members of the International Commission." It would be several days before the women would learn that their husbands were alive.

Since the ghastly incident with the Zairian helicopter, Piot was gaining a healthy respect for danger, among other things. But most of the other survey team members had settled into routines, staying in the more comfortable town of Bumba, driving their Land-Rovers out to the villages, and going house to house completing huge questionnaires on detailed information considered vital to understanding the epidemic. With routine comes complacency, a lowering of both guard and fear.

VIII

On November 26, U.S. Peace Corps volunteer Del Conn told team members in the Yambuku area that his head and back were killing him. The pain came on suddenly, and then hung on relentlessly. Conn, who had previously worked in a small hospital outside Kinshasa, had joined the Yambuku survey effort ten days earlier and was assisting Piot in collecting blood samples and village data. He had also helped van der Gröen prepare microscopic samples of Ebola-infected tissues for study in a field lab the Belgian had recently constructed in the mission. A month later researchers would learn that some of Conn's samples, despite ultraviolet radiation exposure and acetone treatment, still contained live Ebola virus.

Though Conn's temperature was only slightly above normal, team members were worried. They notified commission headquarters that it might be necessary to activate the complex system of medical evacuation that had been worked out in detail after days of negotiations with the governments of Zaire, South Africa, the United States, and France. Those procedures required that Conn be placed under strict quarantine for thirty-six hours and airlifted out of the region if his condition worsened.

While Conn lay inside a room of the mission facility, tended to by Karl Johnson and Margaretha Isaacson, the team tried to continue their survey work.

"But there's no question about it," Bremann radioed to Johnson, "this is a major downer for everybody." Morale plummeted, fear rose.

A Canadian military officer had, coincidentally, arrived a day earlier in Kinshasa with a newly designed portable plastic isolator unit, intended to allow safe transport of contagious individuals.

By November 29, Conn's condition had worsened. His fever was up slightly, blood chemistry showed classic signs of viral infection, back pains were severe, and he was nauseated. In Yambuku, Johnson, Dr. Dennis Courtois, and Isaacson tried to prepare Ebola antiserum from recovered

patients' blood, but power failures shut down their centrifuge and other equipment necessary to ensure safe plasma preparation.

"You can't imagine the fear here," Johnson radioed to Bumba.

Under contingency plans, a military helicopter was supposed to fly immediately to Yambuku, pick up Conn, and bring him to Bumba. Meanwhile, a C-130 was supposed to fly from Kinshasa to Bumba, load Conn into the Canadian isolator unit, and transfer him to Johannesburg, after a refueling stop in Kinshasa.

But the Zairian Air Force's pilots balked again. Fearing Conn might give them the disease, the pilots refused to fly their helicopter to Yambuku. All other options closed, Johnson, Isaacson, and Courtois loaded Conn into the back of a Land-Rover and drove the bumpy road to Bumba, their passenger groaning in pain all the way. All three scientists wore disposable protective clothing and surgical masks throughout the journey, which lasted four and a half hours because Conn could not tolerate the sudden jarring produced by hitting ruts at speeds greater than ten miles per hour.

When they reached Bumba, continued Air Force fear was obvious: no plane awaited them. And panic among the townspeople was so great that the Land-Rover was not permitted to leave the center of the Bumba landing strip. Unprotected from the tropical sun and forced to wear a tight rubber respirator mask to allay the fears of the populace, Conn was miserable. Johnson and Isaacson sedated the Peace Corps volunteer and gave him analgesics to ease his pain.

As night fell, there was still no word on air transport for the ailing man, so Johnson and Isaacson were forced to make do with available plasma and equipment. Convinced their colleague had Ebola, they hand-administered a unit of Sophie's antiserum into Conn while the young man lay in the back of their Land-Rover.

At dawn an Air Zaire "Fokker Friendship" airplane landed, the Canadian respirator on board.

The two doctors studied the isolator for a moment. It consisted of a plastic pipe frame that outlined a space some seven feet long, four feet high, and four feet wide. Suspended from the frame was a box tent of thick, clear, pliable plastic. From the sides of the box tent hung attached gloves, into which attending physicians would insert their hands and arms when they needed to "touch" the patient.

The doctors carefully slid Conn into the isolator, attached an intravenous feeding tube to a device installed in the box tent, shut their patient inside, and switched on the pressurized air device. It seemed to work, but the intravenous feeding device was poorly designed and the feed rate fluctuated wildly.

An assortment of drugs and medical supplies were also on board the aircraft, and the doctors decided to administer strong painkillers to Conn before takeoff. Commission members in Kinshasa failed, however, to provide a file with which the vials could be opened, forcing yet another delay

while the physicians sought an alternative sterile means to unseal the ampules.

Once the Keystone Kops-like operation was in the air, another failing of the Canadian device was noted: it did not adjust well to altitude-induced air pressure differences. Conn grew anxious as the box tent slowly caved in on him, making his space ever more claustrophobic.

When the plane landed in Kinshasa another snag appeared in the commission's grandiose emergency evacuation plan: no plane was "available" to take the patient to Johannesburg.

Johnson, now fuming mad, contacted U.S. Embassy officials, who relayed an air support request to the USAF. A C-141 Starlifter was dispatched from Madrid, arriving in Kinshasa six hours later. During the long wait, fear of contagion once again forced the group to stay at the airport, this time inside an abandoned hangar. The afternoon heat was so great that the isolator steamed up and was soon creating its own internal rainfall.

Although he received a variety of analgesics, Conn's pain was acute, he was running a fever of over 102°F, and the hours inside the wet, coffin-sized plastic cocoon were driving him crazy. His anxiety reached a zenith when the doctors noticed blood oozing out of the tiny puncture hole through which his intravenous feeder was inserted.

Uncontrolled bleeding, Conn knew, was hemorrhaging; and hemorrhaging was the key symptom of Ebola. Conn had to be heavily sedated.

That night Conn was transferred into the USAF jet and flown to Johannesburg. Because of a storm front, the flight was diverted on a huge loop out over the Atlantic Ocean. The doctors felt Conn would be unable to tolerate turbulence, but the diversion added several hours to their flight time.

The plane landed in Pretoria and Conn was transferred to a South African Air Force plane for his final leg to Johannesburg.

When he was finally removed from his nightmarish cocoon, Conn's entire body was covered with a florid measleslike rash that was not usually seen with Ebola but had been noted in some Machupo and Marburg cases. He had been severely ill for six days before reaching a hospital.

Clearly, the commission's contingency plans had failed completely when put to the test. Johnson was enraged, and scientists still deployed in the field were extremely distressed.

Behind the scenes still more misadventures occurred. The CDC sent a massive hospital containment bed isolator by air from Atlanta, but when the contraption arrived in Johannesburg two crucial components were missing: instructions for assembly and an electrical converter that would allow the American-made device (designed for 110 volt, 60 Hz electricity) to function in South Africa (which uses 220 volt, 50 Hz electricity).

Furthermore, early difficulties in transporting Conn prompted CDC officials to prepare an Apollo space capsule for use in South Africa. That forced a major South African Army mobilization of ground transport capable

of maneuvering the eighty-ton capsule. At the last minute space capsule airlift plans were scrubbed.

All in all, the planned thirty-four-hour evacuation actually took over seventy-two hours, at an inestimable cost to the governments of Zaire, the United States, and South Africa.

And when Conn's blood was submitted to repeated examinations, no Ebola viruses could be found. Nor could the South African team find evidence of any other known human pathogen.

Twenty years later, the cause of Conn's bona fide illness would remain a complete mystery.

Conn, it seemed, had "discovered" another new virus.

IX

Don Francis was burned out before he ever got involved in the Sudan episode. Hell, he was burned out before he even got to Harvard.

After two years of chasing down smallpox cases all over Sudan, India, and Bangladesh he was ready for a break. September 1975 found Francis at Harvard University, working on a Ph.D. in virology. With the CDC's permission, Francis was studying in Max Essex's laboratory when the Ebola mystery started unfolding some ten thousand miles away.

When CDC officers called him in October 1976, Francis was a bit flattered at first.

Francis got off the phone and searched out his mentor, Max Essex. He found the Rhode Island-born Yankee, as usual, poring over data, and requested a two-week leave from doctoral studies.

Essex agreed to let Francis take two weeks off; indeed, he later had to talk Don into going when the younger scientist's ego was bruised by learning that, far from being indispensable, he was the CDC's last resort. Every other person on the agency's list had turned down the assignment out of fear.

Word from Zaire had, by early November, been exaggerated in the gossip mills of international virology and finding eager volunteers for the Sudan investigation proved exceedingly difficult. Eventually WHO's Paul Brès gave up his search, bought a Geneva-Nairobi ticket, and assigned himself to the investigation. The WHO team in Maridi would be composed of David Smith (of the Kenyan Ministry of Health), Don Francis, Brès, Irishman David Simpson (of the London School of Hygiene and Tropical Medicine), animal expert Barney Highton (also of the Kenyan Ministry of Health), and Sudanese medical experts Babiker El Tahir, Isaiah Mayom Deng, and Pacifico Lolik. Most would join Francis and Simpson in the south, having made their own way to Maridi via Nairobi or Juba . . . after several days' delay.

Because of the ancient rift between Khartoum and the southern Sudanese

provinces, the federal government decided to stop the epidemic by completely cutting the south off from the rest of the country. It was sort of a damage control approach: many might die in the remote south, but the disease would not reach the more densely populated Muslim north. Absolutely no airplanes, trucks, or other vehicles were allowed in or out of the southern section of the country.

For four days Francis and Simpson begged, cajoled, and bribed their way around Khartoum, searching for a way to get themselves—with a couple of tons of supplies—past the quarantine lines, all the way south to Maridi and N'zara. Simpson, El Tahir, and Francis visited all the Western embassies, pleading for assistance. Much was promised, little materialized. Chartering a private airplane was ruled out: Khartoum and Kenyan officials insisted the entire aircraft would be burned, as a protection against contagion, upon return from the quarantine area.

At long last two large British trucks were found, loaded up, and filled with extra tanks of gas. Unbeknownst to the hapless WHO crew, McCormick had already left N'zara by the time Francis finally got behind the wheel of a truck bound for Maridi. It was the rainy season, and what passed for roads had become muddy rivulets. For twelve hours the WHO team kept their trucks in four-wheel drive and their accelerators floored and endured a battering, crashing ride. It was two in the morning when the exhausted group pulled into the town of Maridi, population 2,000.

They were greeted by the Maridi hospital's night watchman, who awoke the town's two public health doctors and installed the tired team in an old British missionary complex.

The following day further impediments to their investigation mounted, and Francis, Simpson, and El Tahir were frankly stunned by the scale of their problems. The national quarantine of the south was bringing on near-famine conditions in the region. Because the rolling elephant grass savanna was often wet and marshy, it was insect-infested. Tsetse flies, in particular, swarmed about, infecting livestock and people with the trypanosomes that cause sleeping sickness. The problem was so severe that most people had years earlier ceased raising animals, and the entire region was dependent upon shipments of meat and protein from the north. No shipments had come through since September 30, when the quarantine was imposed. El Tahir, who had made the first official visit to the epidemic area on September 26, could clearly see the enormous difficulties imposed on the people by six weeks of quarantine.

The three men also found the distances between villages in the region lengthy and untraversable in four-wheel-drive vehicles. Some of the nomadic villages were virtually invisible, hidden in tall stands of elephant grass, reachable only by nearly imperceptible footpaths.

The district's headquarters, Maridi, was a sparsely supplied government town whose sole significant employer was a UNICEF-funded teaching hospital. Constructed of wattle, the hospital was staffed by two poorly paid

public health doctors and 120 nurses, most of whom were trainees. Their shared skills and supplies pretty much limited the Maridi staff to tender loving care in their constant war against sleeping sickness, malaria, bacterial meningitis, septicemic plague, relapsing fever, and a host of other tropical diseases. Long cut off from the rest of the world, Maridi had no telephones, so a ham radio was used to relay signals to Juba, where a French scientist remained throughout the Sudan investigation, serving as a communications officer, relaying messages to and from Khartoum. There was no communication with International Commission members in Zaire.

When Francis, Simpson, and El Tahir arrived, the two Maridi doctors were already in the process of closing their hospital, most of the nursing staff having either died of the new hemorrhagic fever or run away in fear, carrying the virus and panic with them back to the villages. The handful of nurses who remained were in the process of closing down the regular hospital facilities and tending to Ebola cases in a specially constructed wattle quarantine building.

Wearing respirators, protective gowns, and gloves, Simpson and Francis inspected the hospital and were horrified by their first sight of Ebola. Neither Francis nor the more experienced Irish physician, Simpson, had ever seen anything even approaching its devastation. Weak, emaciated men and women lay about the mud-and-stick chamber, staring out of ghost eyes at the white men. The virus was so toxic that it caused their hair, fingernails, and skin to fall off. Those who healed grew new skin.

Over the following days Francis, the epidemiologist of the group, questioned hundreds of people in the Maridi area, using local schoolteachers as translators. He drew many blood samples and mapped how the epidemic had spread. Barney Highton led efforts to capture animals and insects, hoping to discover the natural reservoir of the Ebola virus, and El Tahir set up a laboratory inside the abandoned Maridi hospital.

They soon discovered that the major sources of the continuing spread of the virus were the funerals; more specifically, the procedures—not unlike those practiced in Yambuku—used to cleanse the bodies before burial. Francis ordered a halt to all the funerals of Ebola victims, promising that his team would cleanse the bodies according to tribal customs.

The people were outraged, and their collective anger nearly destroyed the entire WHO effort.

"I think they're going to kill us," Francis told his colleagues. "I mean it. Watch your backs."

Fortunately, one of Maridi's public health doctors was the son of a powerful local chief, and with the leader's support the people were eventually coaxed into bringing their dead to Maridi. Francis, Simpson, El Tahir, and Brès would take the bodies a discreet distance away from public view, put on their protective clothing, gloves, and respirators, and remove all undigested food and excreta from the cadavers, as prescribed by tribal custom, which entailed hand removal and manipulation of wastes without

evisceration. They would also carefully remove tissue and organ samples for laboratory analysis.

Stopping the funeral cleansings and closing the hospital brought the Maridi epidemic to a halt, so Francis and El Tahir made their way to the even more remote town of N'zara. There Don found Joe McCormick's boxed note, guiding them through the sequence of original Ebola cases.

"Hi Don," the note read. "Found your index case." After providing details, it was signed simply, "Joe."

N'zara was the hub for a population of about 20,000 people, most of whom lived in village clusters of mud huts scattered throughout the surrounding savannas and jungle. The economic center of N'zara was a cotton factory, where some 2,000 men made fabric from locally grown cotton using nineteenth-century machines. Inside the factory conditions were harsh; the tin roof magnified the excruciating equatorial heat, lung-damaging cotton fibers filled the air, bats swarmed out of the roofing periodically, filling parts of the factory with their malodorous guano, and the poorly paid men worked long, exhausting shifts.

McCormick's note explained who had been the first case in the mysterious epidemic and traced the order of subsequent infections. On June 27, well before the apparent onset of the Yambuku epidemic, a man who worked in the N'zara cotton mill fell ill and died on July 6 of hemorrhaging. His death was soon followed by those of two co-workers whose jobs were in the factory's cloth room, the same site where the first man worked. By July about two factory workers each week contracted the virus. By September several workers and their friends and family members had contracted Ebola, and at least thirty-five had died.

Two-thirds of the subsequent Ebola cases in N'zara involved a man named Ugawa, who was comparatively wealthy because he ran N'zara's cultural hub, a jazz club. The factory workers would spend much of their earnings in Ugawa's club, eating, drinking, and buying the sexual favors of the barmaids. Most of N'zara's epidemic evolved from those liaisons.

And it was Ugawa who had enough money to travel to the Maridi hospital when he came down with the disease. Once his virus got into the Maridi hospital, it spread like wildfire.

By the time the WHO team arrived in N'zara in mid-November, the epidemic was on its way out, having sickened over a third of the Maridi hospital staff, forty-one of whom died. It threw the hospital into chaos, from which many staffers fled. Nearly all the staff that got the disease were infected on the job, primarily through exposure to sick patients' fluids.

From the staff, the epidemic spread into the community through several generations of transmission. Later investigations would reveal that the N'zara virus was highly contagious, spreading more than eight generations from the index case, as the scientists put it. The Yambuku strain, in contrast, never spread more than four generations. On the other hand, the Yambuku virus was far more likely to kill those it infected.

By November 20 it seemed the epidemic was over, the spread having halted as a result of the hospital closures and changes in funeral practices. Francis totaled up his case list: 284 Ebola cases, 151 deaths, all but four cases occurring in either N'zara or Maridi. As McCormick had suggested in his report to the commission (which Francis could not see in the Sudan), the Sudan virus seemed less deadly. While upward of 90 percent of those infected in the Yambuku outbreak died, only about half (53 percent) of the Sudanese cases were fatal.

The center of Maridi's epidemic was the hospital, where nearly half of the people hospitalized for other reasons got the disease (93 of 213 patients) and the toll among the medical staff was high.

In N'zara, however, the virus seemed to come, somehow, from the cotton factory, and the WHO team devoted a great deal of time and attention to that building, where nearly a thousand men worked at any given time. Freshly picked cotton came in one end of the structure and was processed room by room into bolts of finished cloth.

Blood tests showed the highest infection and death rates were among the twenty-four men employed in the cloth room: four deaths and five nonlethal cases, for an overall infection rate of 38 percent. Francis and Highton combed the room in search of an animal or insect that carried the Ebola virus. They had no way to test the animals in N'zara, so they were working blind, capturing anything that moved, removing vital organs, and placing them in liquid nitrogen. Eventually, the organs would reach Pat Webb's lab in Atlanta, where she would perform the tests necessary to determine whether any were Ebola-infected.

They found the cloth room heavily infested with bats, rats, cotton boll weevils, spiders, and numerous other insects. By December, Webb would give the WHO team disturbing news: none of the animal samples contained Ebola virus.

Thus, the origin of N'zara's epidemic remained a mystery.

Having already spent well over the requested two weeks in the epidemic zone, Francis was anxious to get back to Harvard. The CDC, however, cabled Khartoum to instruct Don to remain in Sudan. It wasn't until Christmastime that Francis, imbued with a bitterness toward CDC leaders that would color his future activities with the agency, returned to Boston, renegotiated an extension on his CDC leave, and set to work completing his Ph.D. research.

By then, Joe McCormick was back in Sierra Leone, setting up his primitive Lassa laboratory. Karl Johnson had returned to Atlanta. Months later, Pat Webb would get her long-desired taste for exotica fulfilled, when she volunteered to join McCormick's Lassa studies in Sierra Leone.

Joel Breman did not return to his Michigan Swine Flu work. Instead, he devoted two more years to African research on behalf of the CDC and WHO. He joined efforts to search for cases of monkeypox, a type of virus similar to smallpox that produced illness, but rarely death, in human beings.

WHO wanted to be sure that it was safe to cease smallpox immunization efforts; it was essential that Breman find out whether wild monkeys carried forms of pox viruses deadly to humans.²⁰

Throughout the late 1970s and early 1980s human monkeypox case reports would increase steadily, from zero prior to 1970 to 35 in 1983, most occurring in the rain forest regions of Zaire.²¹ In 1984 some 214 cases would be found in Zaire alone.²²

It would turn out that most monkeypox cases occurred in—yes—the Bumba Zone of Zaire in the villages surrounding Yambuku.²³ All sorts of animals living in the Bumba-area jungles would be shown to carry monkeypox: tree squirrels, forest monkeys, chimpanzees, and antelopes. But in the end scientists would conclude that the rain forest virus was not genetically close enough to the smallpox virus to pose a threat to human populations, and the monkeypox virus spread so inefficiently from person to person that *Homo sapiens* epidemics never occurred.²⁴

Breman insisted that the animals and people studied in equatorial Africa during the monkeypox surveys—particularly those surveyed in the Bumba Zone—also be tested for both Ebola and Marburg virus infections. After nearly ten years of testing, no infected animals would be found, although a handful of bats captured in faraway Cameroon would test antibody-positive for prior exposure to Ebola.

The mystery of where Ebola came from would haunt most of those who had been involved in the Yambuku and N'zara investigations for years to come. Guido van der Gröen would spend years working patiently in the highest-security laboratories in the United States, the Soviet Union, and Europe, searching for clues to the origin of Ebola in the virus itself. He was determined to crack the mystery of the organism that he and Karl Johnson had dubbed the Andromeda Strain.

He would participate in two expeditions back to the Yambuku area in 1979, piggybacking on Bremen's monkeypox searches, and would test countless animals in search of the natural reservoir of the deadly virus.

In 1980, David Heymann, who was also fixated on the Ebola mystery, would discover that pygmies living in the dense rain forests of Cameroon had antibodies to Ebola, indicating that they had once been infected with the virus. He would corral support from Pat Webb and Guido van der Gröen, and the trio would spend two months living among the Cameroonian pygmies.

The tall white foreigners would find their African counterparts remarkably receptive to the pursuit, willing to use their awesome hunting skills to capture all sorts of creatures for the scientists to test. Van der Gröen would run immunofluorescence tests on over 3,000 animals of 100 different species, ranging from one-meter-long poisonous snakes to chimpanzees.

Webb and Heymann would eventually discover that 15 percent of the pygmies had antibodies to Ebola, proving that whatever animal served as the reservoir of the deadly virus lurked in the dense rain forests of that

region. But none of van der Gröen's meticulously preserved animal samples would be infected.

Still further into the future, Joe McCormick would continue his search, testing animals in the western Ghanaian rain forests. Because it turned out that the natural reservoir of monkeypox was flying tree squirrels, McCormick would capture and test squirrels. And he would find one tree squirrel that had antibodies to Ebola. But it would not be carrying the virus.

The source of both horribly lethal viruses—Marburg and Ebola—remains a complete mystery.

"There is a strong suspicion that the disease is a zoonosis. Monkeys did not seem to play a role in these epidemics and rodents, or bats, may perhaps be the animal reservoir," stated one of the International Commission's reports.²⁵ A later WHO official report would bemoan that "since the natural reservoirs of Marburg and Ebola viruses are unknown, no control activities can be carried out in Africa."²⁶

Perhaps the bluntest statement appeared in the commission's second report: "As in the case of Marburg virus, the source of Ebola virus is completely unknown beyond the simple fact that it is African in origin."²⁷ But even the assumption that all cases would originate in Africa would prove naïve in years to come.

The commission was, however, able to explain how the apparently extremely rare disease spread quickly throughout the Bumba Zone and Maridi. Knowing why a disease spread could allow local authorities to limit future epidemics to a handful of primary cases, preventing hundreds of deaths. El Tahir put it best: "The hospital must be viewed as an epidemic amplifier." Both in Maridi and in Yambuku the poorly supplied clinics reused syringes hundreds of times a day, injecting drugs from one person to another without sterilizing the needles. McCormick calculated that during the months of September and October 1976, an individual's odds of getting Ebola virus from a single injection at the Yambuku and Maridi hospitals *exceeded 90 percent*. Seventy-two of the primary cases in Yambuku (out of 103) were caused by unsterile needles used in the mission hospital. Sureau calculated that 43 percent of the Yambuku-area Ebola victims who got the disease from another person survived the ailment, but only 7.5 percent of those who were injected with contaminated syringes survived.

At the Yambuku Mission Hospital, for example, the commission eventually figured out that the majority of the early Ebola cases involved women who came to see the Sisters for pregnancy-related checkups. When women were questioned, it turned out the real draw to the mission was a miraculous injection that made pregnant women feel energetic and content.

It was vitamin B complex.

The commission determined that injected Ebola infections were far more likely to result in terminal disease than were secondary exposures to sick friends and family members.

The Sisters did not appreciate this information. Still grieving the loss of

more than half their staff and colleagues, the missionaries would not countenance accusations that the very individuals who had given their lives in a saintly struggle against an unknown horror should now be labeled agents of epidemic spread.²⁸

X

As Christmas approached, Peter Piot prepared to leave the place that had over two and a half months' time come to feel like something of a home. He had long since sold the wedding suit and wing tips he wore to Kinshasa. Gone too was his naïve arrogance. In its place was a new sense of confidence coupled with a healthy respect for the microbial world.

"I have seen things which most Europeans only read about in books or see in adventure movies," he told Sister Genoveva. "My mother, a typical Flemish woman, always taught me, 'Speaking is silver, silence is gold.' But I have seen too much to keep my mouth shut."

As the Belgian packed crates for his departure, another young adventurer was sitting in Kinshasa, eagerly awaiting his opportunity to go to the Bumba Zone. American CDC scientist David Heymann had volunteered without hesitation to be the last foreign scientist in Yambuku, charged with cleanup epidemiology and, perhaps most important, giving the rest of the crew an opportunity to head home for Christmas.

At Bumba's airport Heymann and Piot met for the first time, shook hands, and headed off in opposite directions. Years later the pair would work side by side, trying to control another, far larger, deadly epidemic. Piot recognized the excited look in Heymann's eyes: it was the same look that had filled the now world-weary Belgian's face when he first arrived so long ago.

As Heymann drove Piot's Land-Rover along the road to Yambuku, he spotted boys along the way playing with homemade toys. Throughout Southern Africa, boys made clever sculptures of cars and trucks from cast-off wire, and rolled their toy vehicles along the roadside in imitations of the real ones. But Heymann saw these Bumba-area boys all had made something very unusual: helicopters. Nowhere else in Africa had Heymann seen children playing with helicopters. One boy, seeing Heymann's white face coming down the road, merrily held his helicopter up in the air and then dropped it to the ground, laughing hysterically.

"Wonder what that was about," Heymann thought.

Back in Bumba, Piot was unknowingly preparing for one more undesired adventure. He glanced angrily at the military pilots who were laughing and guzzling beers with fellow officers while the huge C-130 was loaded. The Bumba quarantine having finally been lifted, hundreds of local traders and still nervous families were clamoring for spots on the huge plane, along with their goats, pigs, monkeys, chickens, and sacks of worldly goods. The

task of organizing their boarding was left to Piot, who felt no joy in anticipating another airborne excursion with drunken pilots.

Piot and a few other passengers loaded dozens of crates into the cargo hold, having no idea where it was best to place heavy versus lightweight objects. The anxious pilots left the engines running and occasionally shouted for Piot's group to hurry. The men placed most of the lighter objects at the front of the plane, heavier crates of laboratory equipment to the rear, leaving the center open for passengers. With the few nets and ropes provided by the pilots the group did their best to secure all the cargo in place.

By the time all the passengers were on board, crammed shoulder to shoulder without benefit of seat belts, or even actual seats, a storm was brewing. The pilots taxied their huge, heavily laden aircraft to the end of Bumba's tiny tarmac, revved the engines, and roared down the runway. The plane lumbered, groaned, and bounced, unable to gain height with such a heavy load.

"Oh my God!" Piot cried out, seeing the tree line directly ahead. The pilots pulled the throttle sharply, attaining just inches of advantage over the tops of the palm trees. The plane climbed steadily for several minutes until, hitting a pocket of storm turbulence, it suddenly dove a few hundred feet.

The heavy crates to the rear of the aircraft broke loose of their nets, slamming down on the screaming passengers. Blood spattered in all directions, people screamed in pain, and the inebriated pilots responded by jerking the plane up, causing the front-loaded cargo to snap loose. Piot and his bleeding and battered fellow passengers were sandwiched between heavy crates of cargo, some of which carried thousands of samples of lethal Ebola-infected animal and human tissue and blood samples.

Convinced he was going to die, Piot found himself thinking not of his wife or his past life, but of the epidemic.

"Shit," he muttered, "all that work for nothing. Nobody will ever know the answers."

Piot's fellow travelers became nauseated; some had suffered contusions and broken bones. For the rest of their relatively uneventful two-hour flight to Kinshasa the only sound heard above the engines' roar was the sobbing of terrified and injured passengers.

When Peter Piot staggered off the last of a series of planes into the Christmas chill of Antwerp, he found Margarethe obviously pregnant. And suddenly the full weight of what he had been through since September, of his many brushes with death—some foolhardy—hit him like a bolt.

Still, he had tasted adventure, and Piot would never again be satisfied for long with the seemingly mundane life of laboratory science.

Both van der Gröen and Piot were deeply affected by their Zaire adventures, so much so that Guido, whose emotional fuse was normally so long that few had ever witnessed an outburst from the Belgian virologist,

discovered rage. Dragging Piot along with him shortly after Christmas, van der Gröen marched into the headquarters of the Sisters of the Holy Heart of Maria.

"Our objective here is education," the seething van der Gröen told Piot as they entered the office of the order's Mother Superior.

The meeting began calmly enough, with the two scientists applauding the Catholic education of children in the Yambuku area—an assignation that dated back to 1935. The men also noted the well-intentioned origins of the order's medical effort, which stemmed from its relatively recent recognition that some 50 percent of the schoolchildren were chronically absent from classes in Yambuku due to illness. The order sought to improve school attendance by maintaining child health.

In the early 1970s members of the order had attended several days of basic medical training at the Tropical Institute in Antwerp. That was the full extent of their nursing training before venturing into the field.

"They're not nurses!" van der Gröen uncharacteristically shouted, realizing he was criticizing deceased nuns. Still, he pushed on. He applauded the holiness and devotion of the Sisters.

"But no one was thinking that if you start such a medical business, and the people of the region are receiving no support from the government of Zaire, and you give out free health care, then you must be prepared to be deluged. You must be ready to safely give 300 shots a day. If you build something you call a hospital, then you must do the logistic planning, provide the resources, and train your personnel accordingly."

Van der Gröen's coup de grace was an accusation: "The price for your lack of planning was high"; half the dead got Ebola in the mission hospital.

Piot insisted that the mission hospital should either be closed or be staffed by a certified physician. And both men warned the Mother Superior that the source of Ebola was never found: it could return, and spread again inside the mission if their instructions weren't followed.

Though their advice was heeded for the Yambuku Mission, Piot and van der Gröen left the religious order wondering just how many missionary health facilities of all denominations operated in developing countries with a similarly imbalanced mixture of hopeful devotion and tragically poor medical training and logistics. The two men, who would remain lifelong friends forever bound by their shared Zairian experience, stepped out into the icy Antwerp January morning, their minds and conversation filled with concern for the far-off tropical villages, the women in their *kangas*, the babies tied on their backs, and husbands earning hard livings selling wild animals they captured in the steamy rain forest—a jungle that hid Ebola.

The following Christmas, Pierre Bureau received a letter from Sisters Marcella, Genoveva, and Mariette. He sat in his comfortable Paris apartment, trying to recall the sweltering heat and primitive mission of Yambuku as he read the Sisters' greetings:

Dear Doctor, we wish you a good New Year 1978. These days we talk a great deal about the events of the past year and you, who have left us with good memories. We would like to thank you again, sincerely, for coming to our aid when others dared not to come. At the moment life has returned to normal. A Zairian doctor is here: he also works with all his heart. Four Belgian volunteers and a Sister are here to rebuild the hospital. The students are back in the school, making plenty of noise. Are you well? We send you our affection. Sister Marcella, Sister Geneveva, Sister Mariette.

Sureau affectionately refolded the letter, put the pages back inside their envelope, and put the missive into a carton marked "Yambuku." He carefully shut the box and placed it in the back of a closet.

Souvenirs of a plague.